REPORT RESUMES

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COMPUTERS AND UNIVERSITIES. (A WORKSHOP CONFERENCE PRESENTED BY THE UNIVERSITY OF CALIFORNIA, IRVINE, WITH THE COOPERATION OF THE UNIVERSITY OF MICHIGAN, NEWPORT BEACH, NOVEMBER 8-12, 1965.)

BY- GERARD, R.W. MILLER, JAMES G.
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THE COMPLETE TRANSCRIPTION OF A 5-DAY WORKSHOP CONFERENCE ON COMPUTERS AND UNIVERSITIES WAS PRESENTED. THE PARTICIPANTS CONSISTED OF 54 REPRESENTATIVES FROM UNIVERSITIES AND COMPUTER-ASSOCIATED AGENCIES AND CORPORATIONS. TOPICS LISTED ON THE CONFERENCE AGENDA WERE (1) "COMPUTER-ASSISTED INSTRUCTION, LEARNING ASPECTS," (2) "COMPUTER-ASSISTED INSTRUCTION, TECHNICAL ASPECTS," (3) "LIBRARY HANDLING BOOKS AND THEIR CONTENTS," (4) "COMPUTER-ASSISTED INSTRUCTION, LIBRARY, STORED INFORMATION," (5) "ADMINISTRATION, INTEGRATED RECORDS AND PROCEDURES," (6) "ADMINISTRATION, TOP LEVEL INFORMATION FLOW," AND (7) "REGIONAL AND NATIONAL NETWORKS." (RS)

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A Workshop Conference Presented by the

University of California, Irvine

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University of Michigan

R. W. Gerard, Chairman
James G. Miller, Co-chairman

November 8-12, 1965

Newporter Inn, Newport Beach, California

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
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R. W. GERARD

JANUARY 27, 1967

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PARTICIPANTS

Scott Adams	National Library of Medicine
Daniel G. Aldrich, Jr.	UCI
Richard C. Atkinson	Stanford University
William S. Barker	National Science Foundation
Richard Barrutia	UCI
James F. Blakesley	Purdue University
R. Louis Bright	Westinghouse Electric Corporation
Sullivan G. Campbell	Xerox Corporation
John Cogswell	System Development Corporation
Robert E. Corrigan	Litton Industries
Glen J. Culler	UCSB
Paul M. Davies	Whittaker Corporation
David C. Evans	UCB
George J. Feeney	General Electric Company
Julian Feldman	UCI
Alan D. Ferguson	The Ford Foundation
John C. Fisher	General Electric Corporation
Merrill M. Flood	University of Michigan
Kenneth W. Ford	UCI
Bernard J. Gelbaum	UCI
R. W. Gerard	UCI
Homer Given	IBM Corporation
Ralph E. Grubb	IBM Corporation
Robert M. Hayes	UCLA
Charles J. Hitch	UC
Lee W. Huff	Advanced Research Projects Agency
Francis A. J. Ianni	Office of Education
Keith E. Justice	UCI
James A. Kearns	IBM-UCI
Felix F. Kopstein	Educational Testing Service
Leo L. Kornfeld	Crasap, McCormick and Paget
Edward D. Lambe	State University of New York, Stonybrook
Joseph C. R. Licklider	IBM Corporation
James G. March	UCI
James G. Miller	University of Michigan
Harold E. Mitzel	Pennsylvania State University
Lloyd N. Morrisett	Carnegie Corporation of New York
Joseph A. Murnin	Office of Education
Allen Newell	Carnegie Institute of Technology
Leonard M. Rieser	Dartmouth College
Robert M. Saunders	UCI
Otto Schmitt	University of Minnesota
Oliver Selfridge	Massachusetts Institute of Technology
Harry F. Silberman	System Development Corporation
Patricia C. Simmons	Orange County School System
John E. Smith	UCI
Richard C. Snyder	UCI
John A. Starkweather	UCSF
Lawrence M. Stolurow	University of Illinois
Fred M. Tonge	UCI
Robert D. Tschirgi	UC
Kenneth R. Williams	Florida Atlantic University
John T. Wilson	National Science Foundation
Karl L. Zinn	University of Michigan

This conference has enjoyed the support of the Office of Education and the cooperation of the University of Michigan, Mental Health Research Institute.

PROGRAM

Monday, November 8

7:00 p.m.	Dinner and Opening Session Welcome: R. W. Gerard Daniel G. Aldrich, Jr. James G. Miller Fred M. Tonge

Tuesday, November 9

9:00 a.m.	Session I	CAI - Learning Aspects
	Speaker: Richard C. Atkinson Chairman: R. W. Gerard	
2:00 p.m.	Session II	CAI - Technical Aspects
	Speaker: Ralph E. Grubb Chairman: Fred M. Tonge	

Wednesday, November 10

9:00 a.m.	Session III	Library - Handling Books and Their Contents
	Speaker: Robert M. Hayes Chairman: John E. Smith	
2:00 p.m.	Session IV	CAI - Library - Stored Information
	Speaker: Joseph C. R. Licklider Chairman: Robert M. Saunders	

Thursday, November 11

9:00 a.m.	Session V	Administration - Integrated Records and Procedures
	Speaker: James F. Blakesley Chairman: Kenneth W. Ford	
2:00 p.m.	Session VI	Administration - Top Level Information Flow
	Speaker: James G. Miller Chairman: Daniel G. Aldrich, Jr.	
7:00 p.m.	Banquet	
	Speaker: Charles J. Hitch	

Friday, November 12

9:00 a.m.	Session VII	Regional and National Networks
	Speaker: Robert D. Tschirgi Chairman: Richard C. Snyder	

Monday, November 8, 1965

Dinner and Opening Session

7:00 p.m.

Welcome:	R. W. Gerard
	Daniel G. Aldrich, Jr.
	James G. Miller
	Fred M. Tonge

GERARD: I'd like to open the more formal part of the evening first of all by saying how welcome you all are. We have had mixed concerns in planning this conference since this was to be a working group from which some serious outcome was expected including a published volume. It was necessary to keep down the number to an eyeball kind of size. With well over 400 names of people who would have easily qualified and been interested in attending, this was quite a problem of selection. We hoped originally to keep it to about 30. It got up to about 55 in spite of everything, some people coming only for part of the time. There has been a rash of accidents, disappointments in the last few days, so we may end up finally with about the right number although it will still be considerably over 30. In any event I think we are going to have a very fine and effective exchange of ideas.

I would like to first of all thank a few people who have contributed to the planning and organization. Particularly Mrs. Alice Duran, who has been in touch with you all, and has done as I am sure you will agree, a superb job. I want to officially thank Fred Tonge who has helped in the planning from the start and given me much good advice, and Jim Miller, who will have the chance to welcome you shortly. He, representing The University of Michigan Mental Health Research Institute has also been of great help in the initiation and planning of this. Carol Miller, also from Michigan, who is also going to be and has already been to some extent, of help in running the show. She will be responsible for being sure that you get a really good recording, and hidden behind the screen is Mr. Weber, who has a noble record in first-rate recordings and transcriptions. We will have a complete record of the entire proceedings and part of the arrangments in having support from the Office of Education was that the outcome of this workshop was to be made widely available in the form of some publication. In due time you will be given a chance to edit and supply details and add any references and all those various things that make conferences less pleasant than they otherwise would be. I also invite you all in due time to add such materials as you wish. Several of the members have contributed documents which can be incorporated into the final outcome. We are very grateful to the Office of Education for their support of this meeting.

The planning of this conference really began two years ago when the University of California at Irvine was hardly more than a gleam in the Chancellor's eye. The campus became much interested in this area. It seemed at that time a little premature perhaps to call a conference because the matter was way out on Cloud 9, but finally we did decide that this was worthwhile. The Office of Education lagged a bit in its decision and we're perhaps a year later than we ought to be because in the meantime Cloud 9 has been raining conferences on computers and education all over the countryside. The purpose of this as originally conceived was to catalyze the field in general, or maybe I should say fertilize it, by bringing together potential users, potential producers, and potential supporters in the field of computers in universities and particularly computers in the actual educational process itself. At the time the plan was made, it was a very loosely planned program with an opening presentation and then wide open free wheeling in the discussion. Since so much has happened since perhaps the excitement around the world and in this country is now greater than originally anticipated, I hope we may tighten it up a little bit beyond the original plan. I will tell the rest of you now and the chairmen of the sessions who didn't get to the meeting at which these things were planned some of the hopes. I hope each of the chairmen will, in introducing the session, say just a few words to point up some of the subfacets of it that he sees as particularly presenting problems or opportunities and some of the ways in which this may move forward. The main speaker will, of course, present to the group his view of this field, the opportunities in it, what's being done, where he hopes it will go. Then I hope the chairman in each case will call for brief additional suggestions as to areas that particularly need attention. By that time we'll be at the coffee break and the chairman will then put together some of these suggestions and make up his mind on what one or two or five major threads he would like to encourage during the discussion and try to keep you in order to the extent of dealing with them one at a time and also keep the discussion from ranging so widely that we get off from one day's topic onto another day's topic. The chairmen have also agreed (and I hope those who weren't there will accede to this) to appoint a recorder for each session. They will present a brief summary at the end of each session of what the pair of them consider to be the most important outcomes of that morning or afternoon's discussion, and it may prove desirable and possible to try and get these prepared for circulation during the following session. If not at least the chairman can present in a very few words at the beginning of the next session his picture of the outcome of the preceding one.

I will not introduce one whom nearly all of you know, the Chancellor of the University of California at Irvine, Daniel Aldrich. He is in a way a strange combination of manager, coach, and fullback on the team. The ball gets carried, the plans get made, and we are playing with three times the initially allotted number of students than we originally expected. The drive down the runway a month ago to get up to 200 mile velocity was pretty strenuous, but UCI is airborne and is delighted to welcome you here. It is particularly appropriate for Dan Aldrich to give you this welcome, not only as Chancellor, but because from the very start he saw the possibilities, in fact the necessity, of tying in a modern university with modern information technologies. The first thing he asked me to do when I turned up was to look into programmed instruction and this very soon developed into the kind of programs that we're developing here at Irvine. Dr. Aldrich.

ALDRICH: I'm delighted to not only great and welcome you but to thank Ralph Gerard for his introduction. I'm attending a variety of conferences these days, never quite sure how I'm going to be presented. In fact I'm reminded of a story of the two lions that found themselves in cages in a small town zoo. One was a vicious young, vigorous lion, looking every bit the likes of a lion. He'd stretch and he'd show his teeth and he'd roar and otherwise act mean. The other lion was an old moth-eaten one, who sat in his cage picking lice and contemplating old age. As they were fed the people would come by and throw the old moth-eaten lion a few pieces of bloody meat and flip to the young one a handful of peanuts and a banana. This got a little bit upsetting to the young lion because he actually was the center of attraction, he knew by the way he looked and acted, people constantly visited and looked at him, but always he got the banana and a handful of peanuts whereas the old lion contemplating death or picking lice got the bloody piece of meat. He couldn't stand it much longer and he turned to him and wanted to know why this might be the case. Oh, he said, it's rather simple. This is a small town, there's not a lot in the way of resources available for a zoo. If you'll check the outside of your cage you'll find you're booked as a monkey.

Now from time to time I get set up in one conference being billed as one thing and on another occasion being billed as another, and in the recent days I have been accused as blasting off a little bit early. I don't know whether we've reached the critical velocity or not, but in any event I want to go back to a point in time in stating that my welcome is not one of a figure of speech, it is one of genuine interest in your presence for the simple reason that having opportunity to commence with a fair amount of resources both of manpower and facility to build a new educational institution. I was greatly concerned that we take advantage of the fact that we are unfettered by entrenched notions or vested interest. We have not yet developed the organizational point of view or the problems associated with it. Hopefully we stay clear of crystalizing so soon in our life that we have to fight the organization all the time. And certainly in early conversations about the opportunity that lay before this institution to be, Ralph Gerard has been most helpful, certainly it has been stimulating for me, who has little background in the business of technology of communication science at least insofar as it involves computers and all who are concerned with them. And so as he pictured for me during a visit before I became involved on the campus what our opportunities might be, I obviously was highly enthused about what might take place not only as it related to the use of the computer in research which certainly I have been involved with, but also its use in administrative affairs, financial affairs, the whole business of record-keeping as it relates to finances, business, student life or what have you, the opportunity that is before us in the library, the great difficulties that we have as we pull together book resources in nine campuses of the university and note the rate of acquisition is going to in due time make it very difficult for people to gain access to what is being printed, whether we want to read it or not, each day. How to make that determination and glean from what is available that which will be helpful in instruction. Certainly this whole business of utilizing the computer has a need in instruction and adjunct to the technologies already available, and with discussions with the likes of Ralph Gerard and those who subsequently joined us, Fred Tonge, James March, Julian Feldman, and a variety of others. We are greatly concerned that people who came to Irvine would take advantage of, even though they might not know much about the use of, at least let there be an attitude of being willing to try to learn about how this science and technology might be employed upon a campus. Because if there were assembled at Irvine those who didn't know, nor did they care to know, we'd be no different from any established institution that's been struggling to shift gears for a long time. I think there are among the faculty at Irvine those who have certain knowledge about and interest in the kinds of things that you people are here to discuss, so when I say I greet you and welcome you warmly, it's because it's my impression from discussions that Ralph has had with me and outlining the nature of the conference that is to take place here in the next few days that you are knowledgeable in various dimensions of university life where computers are employed, and hopefully as you exchange ideas those of us who are reaching out for ideas and information to be of assistance in building an institution can profit by your experience and by your mistakes and hopefully set in motion new programs that will continue the thrust of this science and technology of which you are a part. My presence here this evening is simply one of reflecting genuine interest on the part of an administrator who knows little about, but has heard a great deal about what is in store for us. If we can be educated to appreciate what you're able to accomplish, then hopefully we will produce the resources of manpower, facility and support that enable you to do your jobs. I know that Fred Tonge has occasion to remind me periodically, and this is his opportunity and his responsibility to point out how we may shift gears at Irvine to take advantage of that which you are prepared to talk about during this week. So it's a warm welcome and a pleasant greeting that I extend to you now.

GERARD: It's interesting to follow the intellectual history of things. I helped bring some of this excitement to Irvine. I certainly picked it up at The University of Michigan from which I came to Irvine. I have a couple of my mentors here in the audience: Merrill Flood and Jim Miller. I'm particularly pleased to ask Jim to say a word on behalf of the University of Michigan Mental Health Research Institute, which is cooperating in this.

MILLER: Speaking of communications, this equipment we have here is very remarkable. The latest fact I've learned in the field of information sciences is that it has just come back from Viet Nam and is the equipment used by Mary Martin for her performances for the G.I.s there. If any of you would like to have me sing "Hello Dolly" I'll be glad to do that, but after the session is over.

Thank you, Ralph, for reminding me of the fact that I share with Merrill Floor the role of being your mentor. I don't remember exactly what the definition is, but if it means colleague, why this is correct. Actually, if Ralph and I are such old friends that we are doomed, I am sure that no matter where he moves to we will continue to collaborate in one sense or other until we drop over. I think friendship is great. There are some songs about it. I like particularly the quotation "Thank God for your friends, without them you would be a perfect stranger." I think Jimmy Durante was responsible for that.

I am tremendously impressed with the terrific rate at which Irvine has grown from nothing. When I first met Dan Aldrich, there was nobody here and nothing here but smog. This is a modern miracle. One definition of a university is a collection of different departments having a common heating plant. You not only have in common a heating plant, but you have in common, raceways, going from one building to another where some form of coaxial cables or wires or something else that makes intercommunication possible. I think yours is the first university that has been built around the concept of an intercommunicating raceway. Just how it will differ from the intercommunicating heating plant, I don't think we know clearly yet, but perhaps by the end of these sessions we'll be able to answer that.

On the way down, I learned about a new application of computers to highereducation I hadn't learned about before. You know about the professor who talked about the use of honor examination techniques. "This is going to be an honor examination and I want you to take alternate rows and sit in every third seat." Well, actually now, we are going to have honor examinations with the computer because the answers are hidden in there and there isn't any way to get them out. Licklider was the first person that made this point and I was impressed with it. I don't think really that there's anyone here who believes that there is anything that computers won't ultimately do for higher education, but it's just a question of how soon it's going to be. I had not thought it would get into the field of academic ethics as early as it apparently is. I like telling computer stories, because I'm a psychiatrist and there were so many years when all the stories were about psychiatrists. It's very nice to open The New Yorker these days and see the cartoons about computers and their print-outs and so on. I remember the old days when every week when the New Yorker came out I was descended upon by my friends in other disciplines. This doesn't happen so much now. The only problem is that I'm beginning to be associated more with computers and less with psychiatry and I don't know quite what's going to happen to my own future. As I was flying over Las Vegas, I was reminded of a plan that Merrill Flood and I worked out a few months ago, which I think still has promise. If you feel that you're not getting enough support from the legislature, or the regents for your activities, I suggest that you perhaps go into a little private investment in this area and use it for advancing the welfare of your university. It's quite apparent that there are opportunities being lost in the gambling field in Nevada which can be helped by the computer. I belong to the group who thinks the computer can do anything ultimately. This is a field it hasn't gone into as far as it should. I suppose some sort of change will have to be made in the coin box of the pay telephone in order to make this possible, but you could dial up a central computer, and put in your dime or however much money you want, and once a minute there would be a click. The computer would calculate all the money that had come in during that last 60-second period, and then on some random number basis approved by the state gambling board, it could issue signals to the appropriate coinboxes all over the state. You might get the jackpot. I think there's a great deal to be said for this technique because you can gamble at home. I do think those people who gamble at home will be a little disillusioned after a period of time when they begin to realize that what they're getting out of the jackpot is what they're putting in, nothing more or less. But the main complication which people have brought up against this idea, is the problem about doing it across state boundaries, for example into California. I contend that there is no problem this. You simply put bandpass filters about one foot over the California border which prevent the signal which is being sent over the lines, which trips the jackpot, and under those circumstances there's no problem really. Good learning theory will tell you that it'll only be a few weeks that even the most determined gambler will continue to put money into his coin phone in California or New York or wherever he happens to call from even if he doesn't ever get any form of reward. I think if you could buy in on this system perhaps using Fred Tonge's on-line computer at nights or some other times when it's not used for other things, you may well be able to get anything you want for your university.

One further comment I'd like to make. There have been new developments in teaching machines. I don't know whether you all know about the latest experience of Skinner, the discoverer or inventor of the teaching machine. He's been working recently with pigeons again. He has a real skill with those animals and he had been using this skill for some time working very hard on teaching this one particular pigeon to respond in 16 different languages. He finally succeeded in doing that and was so pleased that he sent it to his mother. He heard nothing for some time and so he called her up one night and said, "Did you get the pigeon?" She said, "Oh yes, thank you so much for sending him to me." Then there was silence and he said, "Well, what did you think of the pigeon?" "Oh," she said, "he was delicious!" He said, "Mother, don't tell me you ate the pigeon. Do you realize I trained him to respond in 16 different languages?" She was silent for a minute, and then she said, "Why didn't he say something?"

I believe very sincerely that there are going to be developments of extraordinary importance in this field for higher education, that we are on the threshold of seeing what these applications are, that Ralph Gerard's comments that things are moving even faster than we expected, are accurate. We have together here a group of experts in the field who are going to talk about some problems that I'm sure have not been thrashed through adequately yet and I think we have an excellent opportunity to profit from it—not only the University of California at Irvine, or the University of Michigan but all the universities that are tied together. All of them are going to have to give serious thought to the applications of computer technology, not only to science, as they are already doing, but also to all aspects of the educational process. I think that 5 or 10 years from now it will be clear that Irvine, in taking the lead in this area, has contributed to very important developments in higher education.

We're at the beginning, and as it said in that very fine issue of the newspaper about the session which opened your university this fall: the beginning is the most important part of the work. We're going to be among those who have had the first opportunity of this sort to devote our intensive thought to the most significant possible applications in this field.

GERARD: Thank you. As you compared the psychiatric and computer stories, I immediately thought of a psychiatric story. You remember the psychiatrist who had one of these sectional couches on which he treated patients with split personalities. Well, it turns out we have had that kind of a situation because long before we got into our permanent quarters, we were still sitting in each other's laps in an overstuffed temporary building. We had a computer functioning in a trailer which kind of split it apart, but really kept it together. This was made possible by the organizational and technical and human efforts of Fred Tonge on the one hand, and with the excellent collaboration and joint support of each other with the IBM people, particularly Homer Gibbon and later Jim Kearns so that I doubt if any institution has ever before been born with a computer practically in its mouth like a silver spoon. In any event, this ambience and interest from the top down has already had a tremendous impact on the rest of the staff. The men who have come here, mostly not particularly interested in these matters have become vigorously interested in them. Ken Ford has been responsible for an exciting conference on teaching physics with computers, that has just closed. There will be an extension session at the end of our meeting which all of you are welcome to attend if you are still alive and interested. Many of the other faculty have taken excited interest in developing programs of one kind or another. Our engineering school has a vigorous interest in computer hardware. You will meet these men during the course of the week. Bob Saunders will be chairing one meeting, Ken another, and several others. But the reason I go into this is simply because at this stage I want to introduce to you Fred Tonge, who in contradistinction to myself, who has been merely chairing this meeting, and the two previous speakers, who have in effect been welcoming you and whetting your appetite, Fred will tell you in a little more detail about where UCI is in its trajectory and, I hope, point out some of the problems that he sees which should be discussed in the course of the next few days.

TONGE: Thank you. As one of those who has been snatching at peanuts thrown in the air and wondering where the meat was, I'm glad to speak to you.

It's very difficult to stand up and talk to anybody after they've been exposed to Ralph Gerard, Dan Aldrich, Jim Miller in succession. I can't tell jokes well to begin with, and I can't convey, perhaps, the ideas as well as they can. Also, I see a number of friends here for whom it's almost midnight and so we'll try not to drag on after 1:00 for those of you who flew in today, because I've been on the other end of that one, too.

I'd like to say a few words about what we're doing here to sort of put in perspective what it is that we hope to accomplish at Irvine, where we've got so far, and what some of the problems are. Also I'd like to raise a few questions. I think we're all here to try to learn something from other people who know a lot about things that we don't understand, but are very closely related to what we're trying to do, and to try to show to them what it is that's very important about what we're doing that they don't seem to understand. It's really a very difficult problem, and so from that basis I can pose a list of questions, some of which the obvious answer is, "well you know, that's been solved, and if you read the literature you'd know that. Why don't you stay up-to-date on your field." And for others the answer must be, "well, we've got to learn something about that, we've got to get some date."

First, what is it we're doing here at UCI? We have a joint research agreement with the IBM Corporation under which we are exploring a number of the matters which will be the subject of our discussion the next few days. Under this joint research agreement, we have on campus a 1410 computer, with 100,000 characters of storage. It is direct coupled to a smaller 1440 computer which serves as a communication processer, and we have 18 terminal devices that are scattered around campus that are tied to this, and the computer has a large number of disc units tied to it. It has some tape units, storage, and some printers and card readers, etc. Operating on this system is the IBM Computer Assisted Instruction monitor system which many of you

I'm sure are familiar with, and which you'll become more familiar with as the meeting progresses. We have tried to add to this system a number of other capabilities operating under the same monitor so that from any terminal the student may use course material as it is being developed and may do a number of other things for faculty or staff. Administrative people may also use the terminals and use the system. Probably before I talk a little about what some of these other things are I should point out that as I see it, at least, we've had two sorts of goals which we've kept to and which have shaped what we've done. One, we have made a very definite separation between the computer facility and academic programs in computer science. The computer facility is not the child of computer science or information science and vice versa. The hope of doing this, of course, was to try to guarantee that we would have some responsive computer center there that would serve people. Not just those people who want to play with computers, but those people who wanted to use them in instruction, wanted to use them in administrative work, etc. The other approach that we've taken, and so far it's in terms of talking and planning, and not in terms of action, because it's never been tested. We have thought of a central computer facility with possibly a number of satellites tied to the central process, direct coupled, or at least tied to the central processer by communication lines, with terminals both off the satellites and off the central computer, but not a bunch of different computer facilities around campus doing separate things. One of the questions

I hope that we will get around to is whether in fact this is a feasible approach in terms of today's technology and tomorrow's technology.

Well, what are we doing with computer system that IBM has provided? There have been three goals spelled out in the joint research agreement. One is, Computer-Assisted Instruction. Perhaps we should say this was suggested at the physics conference last week. Computer assisted learning. Another is use of the computer in administrative applications and systems in the university. The third is, use of the computer in the library. UCI and IBM jointly have felt that computer-assisted insturction or computer-assisted learning doesn't mean simply typing out questions to which students respond and then giving cues, and different hints, etc., but includes the computational use of the computer when appropriate as a part of instruction. One of the first things we have done is to put a computational language, the JOSS language developed at the RAND Corporation, on our system. Like everyone in the computer business, I'm using the future perfect because it isn't quite working yet, but we talk as if it were done last year. Parts of JOSS are working, and other parts will be working. We chose this language for a number reasons. One, because we were unable to work closely with RAND in getting details of it and another is because it looks like a very good language for instructional uses, although it is not the answer for the research computer.

In addition to JOSS we have active work in a number of areas, particularly in social science on development of course material, and also development of course material in the freshman programming course. We have, I think, 250 freshmen this quarter taking an introductory course in programming and will have more next quarter, so that we hope that in general from the beginning our students in the social, behavioral, physical, and biological sciences and in engineering will be able to use the computer as a tool. In addition to this, we are beginning work in these other areas: administration, data processing, library. In particular, we're emphasizing two initial areas in administrative data processing. One is enrollment. The notion is that from terminals scattered around campus, students will be able to pre-enroll during a predefined period of some length, say three or four weeks, toward the end of a quarter, and we will then be ready to proceed into class. This has a number of advantages one can see, that if you learn before you get there what students want to take, you don't have half-empty sections at the last minute. We have no foreign language requirement, no freshman English requirement, you name it, we don't have it! It's very important to try to get this kind of feedback early in the game. Now again, this is a goal. In our first enrollment we tested some parts of the system in parallel with manual enrollment. The intention, and the way things are working, we will, in fact, do enrollment for the winter quarter on a preenrollment basis during the end of the fall quarter, but it will not be in terminals all over campus. It will be controlled, and I think it will be done that way for a while, because as those of you who have undertaken administrative applications know, the problems of handling input that is not formated, not by trained secretaries is pretty horrible. I think this is a problem one has to beat. It shows up in Computer-Assisted Instruction. Someone jiggles the capital up-shift/down-shift too many times, or he uses a slightly different word, or a plural or something, and all your beautifully conceived pedagogical plan for giving him hints goes right down the drain. But at least in enrollment, starting with that as a base, which requires the building of student files, the building of course schedules and all, we see a first application which will be a good place to broaden out. Similarly, we have, at about the same state, a system whereby departmental budget is kept for access from any terminal. When I say from access from any terminal, obviously you can't have it for access from any terminal. Again deliberately we raise some questions of protection which we want to solve early, but the notion here is that the departmental secretary will be able to keep this up-to-date on a fairly regular basis, she and others in the department will be able to inquire as to the financial status. We'll be a lot better off than we are depending on the traditional systems which require duplicate bookkeeping and have a long time lag in them.

Similarly, we are beginning to work with the library in development of the acquisitions system. The University of California has instituted two operations. The Institute for Library Research at UCLA is studying problems in the library, and a task force, which is attached to the Institute, but is not research-oriented as such, is trying to bridge that development gap. They go around and help the campuses in applying technology to their operations. As would seem reasonable, the various campuses divide up the job. Someone will worry about developing a cataloguing system, and someone else will worry about serials, and Irvine has agreed to look into the problem of developing a system for acquisitions, which will be remote-terminal based. We're pushing this, I think, at some expense to ourselves in terms of manpower, but I think we're learning a lot in insisting that everything that we do like this fit under the same monitor system, which was really not designed for this kind of thing, be available from all terminals, with control, and really trying to see if this notion of a central computer facility can work.

Well, I'm not really sure that it's appropriate at this time to go into a list of problems that I see. I raised one a moment ago with Oliver Selfridge which was on my list, and maybe he'll get a chance to answer it to the group in one of the sessions. That was "What are we supposed to have learned from Project MAC?" I don't ask this to put him on the defensive, but one of the problems in using computers has been we all have slightly different computers and slightly different monitor systems, and slightly different programming systems, and so on down the line.

You can say, we learned you can do that on a computer. Okay, what did we learn after that? Is what I know that now we can hire a programmer and he starts all over and does it again? I think we have some very real problems here.

GERARD: Thank you, Fred. I can't resist repeating something that I said the other night to the physics group because I feel so strongly about it. This is sort of one's emotional mood towards the whole thing. This is mostly future perfect, and present imperfect and not really coming to grips with day-to-day problems. I am sure that I am not as cautious in my expectations as I would be were I in direct daily contact with them. But it is nonetheless true that the following has been my experience in the last two years since I began to seriously go into this field. Two years ago plus a few months, I made a point of inquiring about some various aspects of this. Here's what we want to do at Irvine...the miltiplex machine and the multiple functions and terminals online and parallel processing and the simple communication language and a large fast memory and quick turn around time and all the rest of these things. And they said, "Oh, yes, yes, these things are all technically possible, but it's going to be fully ten years before they are realizable." Well, I continued to push ahead, nonetheless, and worry about it, and the year after that I took another sounding of some of the same men and some different ones, said, "yes, yes, this is fine, this is really what's going to come, but it's three years off." Then, not half a year or so ago at the meeting of the IIIE, in Los Angeles, I heard one after another of the papers indicating how this was now being done, and that was being done. Finally a man from the telephone company who was unfortunately unable to be here at the last moment, got up and said, "now we have all these various things and they're available on the market and I see no roaring demand for them. I was the next speaker, and I jumped up and said, "here's your roaring demand in education. Let's just have them delivered." A few months later this is now old hat and everybody around the world is taking it for granted that these things are here or will be here in the near future. I think, as far as I can judge it, there has been the same kind of unrealistic conservatism as there is in the projection of students in the University of California. It always moves much faster than expected.

Tuesday, November 9, 1965

SESSION I

9:00 a.m.

CAI - LEARNING ASPECTS

Speaker: Richard C. Atkinson

Chairman: R. W. Gerard

GERARD: The chairman will normally make a very brief opening statement. We will then have the main exposition of the area. There will then be an opportunity for those of you around the table to indicate very briefly points that you particularly want to have in the discussion during the rest of the session. We will discuss them at that time. I will take notes and so will the recorder, who is Karl Zinn this morning. During the coffee break we will plan to pick out a few of the very interesting, it may be in order to indicate the order in which suggestions are made and the ones you particularly discussed. Then during the remaining session the chairman will attempt to keep the discussion organized at least to the degree of getting those threads in order as much as possible. I remind you of the topics of the various sessions, so try not to let yourself be led off the discussion into an area that clearly belongs in some later session. If it is something that belongs in an earlier session and didn't get covered then, of course, that is all right. We do need to have complete recordings, and publication is expected by the Office of Education, which accounts for the very fancy boom-type microphones. It will help very much if you will mention your name before you speak, not so much for our information, but for the transcriber who will not see your faces and who will take some time to learn your voices. I remind you again that the Thursday Session will close a few minutes early in the morning and we are expecting you all to come over to the campus, have lunch in our commons, visit the computer facility and pick out some programmed instruction, if you are interested. Thursday evening there will be dinner and a talk.

There are no formal plans for the lunches today and tomorrow or for the evening today and tomorrow. Several of the local people will be happy to entertain you, or you may prefer to do something on your own at that time. Any of you who feel at loose ends, let me or someone else know. Are there any other important matters bothering you before we move on? If not, let me do my job of introducing the subject. Since it is the formal opening of the whole Conference I'll make a somewhat more general statement.

In my opinion, probably the most important outcome of the impact of computers on universities will be to add the dimension of science to the existing dimension of art in the field of education. Of all the areas of applied behavorial science, education is certainly the vastest. As far as I know, it is one of the last of the important areas to take advantage of the growing understanding of computer technology which is being presented to us. It is a little bit like medicine half a century to a century ago. Medical practice grew from the almost completely empirical to the present state, which is very heavily but by no means entirely scientific and social science and engineering skills which have been blended into the medical background. We have had so much taxonomy in our experiences in higher education because of dichotomy of teaching and research, which at the graduate level creates the major problem of the distribution of professor's efforts. Even in Washington granting agencies there is an enormous difficulty in finding just the kind of support one wants unless the proposal is very clearly an educational matter or very clearly a research matter. What I hope is going to emerge very rapidly is something that is not education or research but is research in education. This is certainly an important outlet for men who have a commitment to the teaching function and through universities at present are given a rather short trip because they are very nearly a skilled teacher. I think research in teaching, the ability to fuse the teaching and learning viewpoints through meaningful experimentation to think of teaching and learning not as entirely separate aspects but as a unified problem, is the important outcome.

This conference is concerned with the total university system: all the ways in which newer technologies and insights can improve a university as a total institutional system. The first three sessions, today's exclusively and tomorrow's partially, focus on the salient aspect of this situation, which in our judgment is the use of computers in the instructional or learning process itself. This morning's session deals with the learner primarily. It may not be clear from the titles, but we are hoping that the actual hardware problem of programming languages, this sort of aspect, will be centered more in the afternoon session. This morning we will be concerned primarily with the learner. I would like to throw out a few areas in which I am preoccupied and in which I hope discussion will flow. I suspect that they are all in Dick Atkinson's outline.

First of all, what kinds of subject matter material are most appropriate for using computer assisted learning, or computerized instructions? In what manner can they be used to substitute for a lecture function or discussion leader in the laboratory, for whole courses, for chunks of courses, or as separate problems that can be filled in afterwards? As an examiner, following the learning process and independently concerned with the certification of mastery, or perhaps without any further examination?

Then the third area, I indicate kinds of material, manner of use, as the problems of program design, which I am sure you will hear about somewhere. What balance between passive and active participation on the part of the student should there be? To what extent does he just answer questions? To what extent should he be able to take the initiative and ask them? What kinds of questions should he be able to ask? When can he ask for help or for interaction?

The problem of the use of appropriate patterns in the network, looped branches, length of step, these are all familiar problems, I can't imagine they will be discussed. But how can the computer learn to improve its interaction in terms of the record it builds up with student performance as they go? What can we do with the information that it develops regarding students? How much of the great amount of accumulated information should be fed back to the student, to the immediate instructor, to the counselor, to the people who have to rebuild the course, to the programmer?

All these questions are obvious. Then a more practical question should come out more in the materials and in the discussion: What are the materials that are really available in this area? What actual outcomes are there that can be documented and validated in speed of learning, in retention, in kind of learning that has been possible? What skills can one teach, and so on?

And along with that, what are the dangers of computer-aided instruction? Many people see only the dangers and are practically unable to go beyond this dehumanizing influence. And then, if there is time, I would like, not as an immediate but as an extremely important topic, to discuss the economics of the whole matter.

Now I will ask Dick Atkinson to tell us what, from his vastly greater experience, he feels in this area. ATKINSON: Thank you. I am not sure I can add a great deal to that long list, but let me try. First of all, let me say that my remarks are going to be quite informal and I hope you will feel free to break in at any time with questions and comments. If we do end up with a formal document of this conference, I am sure my behavior will be typical of my behavior in the past. When it comes to editing, I write a set of notes that are completely different from what I said at the conference. I am not going to go into a great deal of detail but I feel that I have the details to back up my statements and when you are interested in a detail, please ask for it during my talk or during the discussion period. I think everyone here is familiar with the concept of computer-assisted instruction (CAI). I feel no requirement to provide a general introduction in the field. What I am going to do is give you some overviews of the field from my viewpoint, from the viewpoint of an experimental psychologist, primarily interested in the process. Last night and again this morning, Dean Gerard suggested that possibly the term "computer-assisted instruction" was not the best one and "computer-assisted learning" might be a more appropriate term. Since I come from a background of learning theory and learning application, this immediately appealed to me; but coming from Stanford, I am always a little cautious about remarks that are made by University of California professors. So after giving it some more thought, I decided that "computer-assisted learning", abbreviated CAL, would really give the University of California a little too big an edge in this book. So I am going to stick to the term CAI.

I hesitate to begin by listing features in computer-based instruction, but I am going to because I think I have a few remarks that are slightly different from the typical list of advantages. One of the advantages that is always listed for computer-based instruction is the possibility for individualized instruction. I think everyone is coming to the view that developments in society make it increasingly more important to individualize the instructional-process, and that the only really serious hope for individualization comes within the framework of a computer-assisted system.

Why are we interested in individualizing the instructional process? Primarily because we view this as an optimal way of carrying out instruction, certainly for a good part of school learning, using the term in a technical sense. For a good part of school learning it seems reasonable, and there is evidence to suggest, that individualized instruction is the appropriate direction in which to go. Of course, this implies that we believe that this is the optimal way of carrying out instruction. I like to distinguish between two concepts of optimality in this framework. Later I will be talking about what I refer to as the theory of instruction, and I think this distinction is worthwhile. One is what I call short-term optimization and the other is what I call long-term optimization. I think every program that has been written, except possibly programs that were developed by scenarians, have used the notion of short-term optimization. By that, I simply mean that the program takes advantage of very current information and then tries to branch or modify the instruction routine as a function of that short-term information. For example, the program analyzes the type of response the subject makes and if it is an error response, analyzes the nature of the error and tries to give remedial instruction which is appropriate for that type of error. This is to be contrasted with long-term optimization where one utilizes the entire history on a given individual in terms of making decisions about what should be done next. Here I like to introduce the term "sufficient history". It's very queer that no theory of instruction is ever going to use all of the information that we have on a subject in terms of making decisions from one moment to the next. Even in terms of these long-term optimization schemes only a sample or part of the history is going to be useful. Of course a part of the history that we use in making these long-term optimization schemes will depend on our theory of instruction. I use the term "sufficient history" in the same sense that the statisticians use the term "sufficient statistics". That component of the history on a given individual allows us, within the framework of the analogy of the statistical model that we are working with, to make an optimal decision. I think one of the problems in any computer-based system is to make use of the potential for long-term optimization to come to some understanding of how one uses this history to define a sufficient history and then to optimize from moment to moment. I think a number of people argue that computer-based instruction is really nothing more than a tutorial system, that we are providing nothing more than a simulation of the instructor on a one-to-one basis with the subject. Here, I would like to point out that I think this is not quite the case. I doubt if any instructor, no matter how knowledgeable, how careful his records might be, could really teach currently the amount of knowledge necessary hopefully to make optimal decisions. It is like the old discussion in psychology about whether clinical or statistical predictions are most effective in terms of clinical classification. I argue here that in terms of these long-term optimizations the computer really provides us with advantages that even skilled instructors in a tutorial situation do not have.

Another general feature of computer-based instruction that Ralph Gerard mentioned is the development of curriculums of materials. He used the term, and I think appropriately, moving this development from the area of art into the area of science. We have continuous feedback on materials, we are continually evaluating these materials. We have a way by which we can make changes and then get a fairly detailed evaluation of the nature of these changes. Again with regard to this topic I would like to use the term "total curriculum". I will define that term more precisely a little later, but the notion of the total curriculum in the framework of the computer-based system as opposed to a typical curriculum is that in the typical curriculum one prepares a textbook and a manual for the teacher and that's about the extent of it. There may be some special classes for the teacher which apply to that curriculum. In contrast, in the computer-based environment one specifies the curriculum in complete detail to the point of every potential audio message that can be used, every potential branch that is possible, every potential response the subject can make and so forth. In addition, one has to spell out how this total curriculum or how this computer-assisted sequence of instruction is fit into the day-to-day curriculum, independent of the computer laboratory.

I hope to give some examples of that in terms of our development.

Finally, the third general feature I want to mention is with regard to behavioral research. The physical sort of experiment that is carried on in learning usually involves a group of subjects being run for an hour, or, at the most, two hours. The reason for the short period of time for the learning of skills is the necessity of carrying out the experiment under highly controlled conditions. The theory that the experimenter is working with generally requires that he obtain detailed protocols of the subject behavior in the situation, a second-by-second accounting of what the subject is doing. In contrast with the extreme, you have your typical educational experiment. The sorts of experiments that were recently carried out on the initial teaching alphabet are a good example. We will introduce one, two, or possibly three different methods of instruction or types of curriculum materials. These are used for a year or so and then at the end of the year you give a one hour test. On the basis of that one hour test and casual observations you make an evaluation of the materials. In both areas one is usually relying on a sample of about one hour of detailed data. The advantage of the computer-based environment is that we are now going to be able to carry out experimentation on the instructional process under more precise experimental control than we have ever been able to in the typical learning laboratory. Further, we are going to be able to carry out this experimentation on a long-term basis, that is, we are going to have individual records for at least 100 subjects for at least 9 months, possibly longer in the Stanford development. And finally, we are going to have a complete and precise recording of information from moment to moment. One of the problems is that we are going to have to collect too much information and the question is how to sift through this information and ask meaningful questions.

All three of these features form a base of what I like to call a theory of instruction. By that, I mean a theory which tells us something about how we seek to sequence materials, how we sequence from concept to concept, and it should do it in several ways. It should give us some gross views of developments in sequencing problems and it should also give us some very precise mathematically exact methods for sequencing. I will try to talk about these somewhat later.

Let me say that I think developments over the last ten years in curriculum reform in programmed instruction, in mathematical learning theory and information processing models make it feasible at this same time to offer at least the beginnings of what I would like to call a theory of instruction that is really going to assist the person who is involved in curriculum planning and will yet have clear implications for the person primarily interested just in research in the area. We would like to distinguish between two levels of CAI systems. One is what we call our Drill and Practice system, two is what we call our Tutorial system, and three is what I refer to as our Dialogue system.

Let me give you an example of our Drill and Practice system. This is at the lower grade levels but I doubt that the example is so terribly different from what might be done at the college level. We now have a group of teletypes in schools located around Stanford University. These are tied to our computer by telephone lines and we carry out daily instructions in drill in mathematics and drill in language arts. At this point we are trying primarily spelling for the 4th, 5th, and 6th grades. It is in no sense a total curriculum. It is strictly a drill and practice system in the sense the teacher carrys on her standard instruction. Whatever she would be normally doing in her classroom, she continues to do. However, once a day for 10 minutes each students comes on the line. Currently, different schools are involved in different programs but, for example, in spelling the student would type his name on his console and that would pull up a program at Stanford labeling him according to his performance on these spelling drills over the previous set of days. Then it would specify a list that he was to work on that particular day, then over the audio would come a set of instructions, and then, depending on the particular program, for example, "Spell the word "cat"," and the student would start to type out the word "cat". If it was correct he would be told, "Yes, that is correct and you can move on." If it was incorrect, appropriate branching would occur. He would continue on through the course of 10 minutes working on that particular material. We are running about 60 students a day now. At the end of the day all students are run through, the teacher gets a printout regarding each student's performance, the performance of the class as a whole, and the particular difficulties that the class as a whole has with the material. Then the teacher can use this information if she wants to modify her teaching instruction during the normal course of the day.

Why do I call these Drill and Practice systems? They are certainly not an integral part of the regular curriculum, rather they are peripheral to the outgoing activity of the teacher; but they do give the teacher a certain relief in the sense that she no longer is responsible for these practice and drill activities. There is not a great deal of data backing us up, but in our experience students enjoy very much interactions with this type of terminal unit. We have now had some children working for 3 and 4 months on the mathematics routine. They are all very pleased with it and their level of performance is moving up at a rapid rate. That sounds like a rather unfounded statement but maybe I can document that later on.

The major point I wish to make about the Drill and Practice system is that it is really a supplement to the standard curriculum. If it breaks down or if it is removed for 3 months or what have you, it probably would not really affect the level of instruction a great deal.

The second type of system is what we call a Tutorial system. This is the sort of system that will be carried on for instruction in initial reading and initial mathematics next year. I'll be talking about that in a moment. The point of the Tutorial system is that in this system one really expects to carry on all of the instruction in a given area in the framework of the computer-assisted system. Of course, one is going to have to introduce the teacher to the special problems of this system. The teachers are going to have to be familiar with the material that is being presented over the Tutorial system and they're going to have to understand the sorts of supplementary activities that they can engage in. But when I talk about the Tutorial system, for example, in the area of initial reading, I assume that a student could, in fact, learn to read by only attending to one of these based terminals. The other activity may be valuable, it may be enriching, but I view the Tutorial system as essentially self-contained, at least in some minimal sense.

The third sort of system that we like to talk about is the Dialogue system. We have made no progress on this and are really not even thinking very seriously about the problem, but I think there is some potential in this area. This is a system that would really provide for rich interaction between the students and the terminal, much richer than in the Tutorial system. When I describe our Tutorial system you will see that our interaction is limited to a light pen that permits the subject to probe the surface of a CR key and also to a typewriter input. Again there are constraints on this page of the input of the typewriter. Hopefully,in a Dialogue system,the students would begin to ask some very sophisticated questions and the computer would not simply produce prestored answers to these potential questions but would actually respond to the particular details of that question and provide an answer that seems appropriate. This may seem a little farfetched but I think it is possible.

I was particularly struck a year or so ago by interacting with Colby's program for psychotherapy. Professor Kenneth Colby of Stanford has developed a program which in some sense is viewed as stimulating the psychotheraputic situation. The subject speaks into the computer via a typewriter. Colby's program then makes an analysis to these inputs and actually responds, and the method of response at this point in time is very simple. The point is that one feels in this situation that there is quite a rich interaction between the computer and the student. Hopefully in time, we are going to be developing CAI systems that do have this capability for a true dialogue between the student and the terminal.

Of course, related to this topic is the whole problem of a speech analyzer. It would be very nice indeed if one could permit the subject to use spoken language and have the computer respond to the spoken language. It seems like a terribly difficult problem. Let me say that I have some encouragement along these lines, I have been working casually with a professor of music at Stanford. He and another person, have developed a device for analyzing tone input and evaluating the picture of the one inputs. He is planning to use such an input device for instruction in music. Of course, if such a terminal device is perfected, then one could tie it to a computer and carry out some of this instruction in the computer-based environment.

Given those three catagories, let me describe the Stanford process. We have been under way for at least two or three years now. We have been carrying on this Drill activity, hopefully on a day-to-day basis. But the system, as you might guess, is not available every day. We have had about a year of experience now in carrying on instruction in first grade mathematics on a semi-routine basis. We have also been carrying on a certain amount of simulation work on initial reading, that is, we programmed up the various parts of the initial reading program and have those on-line in the computer setup, and we are carrying on limited tests of our particular program. We also are carrying on experimental programs in the area of optimization models.

This is more than the framework of straight experimental psychology: we are testing various models of learning in terms of the implications these models have for optimal schemes of presenting material. And that is our current effort with the current system.

Sometime this year we are going to receive delivery on a second system that is being developed by IBM, which is going to be controlled by an 1800 computer. We are currently constructing a building on one of the school sites in Palo Alto, in an area called Ravenwood. Next fall we will have 16 terminals in operation and will be carrying on all of the instruction in first grade mathematics and in first grade initial reading for this particular school. There will be 5 classes in the first grade with roughly about 30 students in each class. It is an interesting population. It is about 82% Negro, there is about a 12-14% turnover per year in this group, rather a low turnover. This year we are collecting a lot of information on these students, who are now in the kindergarten, which we will add to what I call the "Sufficient History" and hope to use in terms of long-term optimization schedules. One piece of information that you may find useful is that the average IQ in this group is 94. Our plan for instruction is roughly as follows:

Some students will have computer-assisted instruction both in reading and mathematics and others will have only mathematics or reading. Our plan for the students who will have both reading and mathematics is that they will come on for half an hour in the morning for reading and half an hour in the afternoon for mathematics. Students who are taking just mathematics or just reading will receive only half an hour in the appropriate area and their instruction in the other area will be in the classroom under typical conditions. We would have preferred to have run all classes under both reading and mathematics, but with 16 terminals and a six hour school day it just was not feasible. Our initial thought a year ago was that we would stretch out the school day to about eight hours so we could increase the numbers, but given the amount of down-time we have experienced during the course of this year, we decided to become somewhat more conservative. If the system is up six hours a day on the average of four days a week, we are going to be happy.

I think it is worthwhile commenting on a few details of the curriculum in reading because I think it will give you a feeling for some of the problems. We have developed a two-year curriculum in initial reading. The theory now is in terms of the linguistic theory that underlies our particular conceptions of the reading curriculum. But in terms of the mechanics we define essentially six levels. Each level is characterized by between 30 and 40 lessons, so the total curriculum in initial reading consists of about 200 lessons. We view those 200 lessons as spanning roughly the first two years of initial reading instruction. You might ask why we have developed so many lessons if we are really interested in handling just the first year. Our experience in the past is there are fantastic, almost unbelievable, variations among these children. Some will spurt ahead at a fantastic rate and others will move at a very slow rate. We want to have enough curriculum material developed that we can provide at least a solid year of instruction, hopefully for even the brightest students in our group.

Now let me give you some details on the curriculum not in terms of linguistic properties but in terms of the operating characteristics. First, let me characterize the terminal units. Terminal units are CRT tubes, character generators, vector mode generators. A light probe is an input and a typewriter is an input. In addition, there is a film strip and a film strip projector which allows us to project any one of a 1000 film images. It is a random-assist device with very high-speed access from any point in the film to any other point. There is also a random access audio system such that we can, depending on particular response at the particular sequence of instruction, pull out from prescored bundle the appropriate audio message. We estimate from our current simulation that a lesson should take our average student approximately 45 minutes to complete. When I say that a lesson takes 45 minutes what does that mean in terms of backup? How much audio do I have to prepare? Roughly, we record about two to four times the amount of audio to the 45 minute period. That is, in order to put a 45 minute lesson on the air with all of the appropriate remedial branches, so that if one student has difficulty he can branch off to remedial material, bright students can branch ahead, and so forth, it takes roughly four times 45 minutes of audio messages. We have to store three hours of audio messages for every 45 minutes of instruction and a comparable figure would hold for the preparation of CRT displays. We make only minimal use of the film strip projector. In a given lesson we use only between 12 and 15 film strips. We try to minimize the use of the film and rely very heavily on the audio and on the CRT displays. In order to back up 45 minutes of instruction we have to prerecord about 3 hours of audio. And, of course, during that 45 minutes of instruction the audio is probably only on about 70% of the time or even less. So you can see how much audio is necessary to back up that amount of instruction.

One other thing about preparing the curriculum. We are working in a language much like Course-Writer II but far more sophisticated. We are quite pleased with the language. The most encouraging feature is the following though.

We have looked at our two years of curriculum materials and have analyzed them in quite a bit of detail at this point. We are now programming in terms of this language and find that we can program the two years instructional material within the framework of roughly 40 macros. In 40 macros we feel that we can program about 90% of the curriculum material. The other 10% is specially programmed statement by statement but for 90% of the curriculum material we can get away with roughly 40 macros. This means we call up a macro, introduce the appropriate argument - which really gets quite complex, of course - namely calling for certain audio messages, describing the particular visual display, and so forth. But, it does mean that the problem of coding up the material is not as horrendous as I once though it was going to be. And all I can say is that your conclusion at this point might be, well they must have terribly simple instructional material. I think the 4 to 1 ratio on the audio will give you the feeling that our instructional material is terribly rich in terms of the branching capabilities and the fact that we can get away with this number of macros.

We have built into our system a number of optimization procedures, most of which are short-term optimization procedures: We have many built in because we have no feeling yet as to how effective these different optimization procedures will be. In essence this will be an experimental program, trying out many different optimization procedures and determining which is the best. Most of these optimization procedures I am referring to are mathematically exact, that is, they require a certain number of computations. In fact, most of them are in the framework of dynamic programming models, requiring a certain number of computations from moment to moment before the next decision is made. In the long-term optimization we have really nothing serious to say. Available in the program is a continual bank of counters which get and keep a long-term record on the subject, and hopefully we will be able, after a year or so, to correlate that record with certain behavior of the subject and come up with some more detailed way of handling this long-term optimization. Of course, we really have certain ideas as to what is the optimal procedure for introducing concepts and later on we will have to modify our program and see if alternatives of introductions or sequences of concepts will really make much difference as to whether we do have what might be called an optimum sequence.

One of the beautiful advantages of the computer-based system in our particular program is that without too much trouble we can literally take big parts of our curriculum and move it around and,consequently, change the sequencing order without completely revising every momentary aspect of the curriculum.

To someone who gets involved in this, let me say that there are a lot of side problems that one needs to keep in mind. One is the whole problem of teacher training. When you move into a school, in the sense we are moving in, it is necessary in the preceding year to take the teachers, not only in the classes you are going to be dealing with but in the classes from the kindergarten up to the 4th grade, and give them a fair program of instruction. They have to become quite familiar with the curriculum materials in the year; they have to become quite familiar with the system of operation; they have to become quite familiar with the possible supplementary activities that they can engage in; and finally they have to get familiar with the sorts of outputs that we are going to be giving them each day on each child. I am sure many teachers will ignore these outputs but just look at the gross outputs for the entire class. Of course these outputs are available and the bright responsive teacher will try to use these outputs in interacting with the children when they are off-line. Our system is,we hope,fairly complete - we program for a number of contingencies. For example, we have a teacher call - our plan is that there will always be two proctors available. Programmed into the lesson material are certain counts that we keep track of in terms of making too many undefined responses, making too many responses that fall beyond a reasonable time period, in fact, making too many error responses of particular sorts. When this number reaches some period, it fires a message off to the proctor terminal and the proctor terminal will read, "Station 11 - reached a problem at point such and such." Then it will give a reference to a booklet of material and it will say, "Criterion reached on the number of overtimes for this student." The proctor may decide to go over to that terminal if she has time. If she doesn't have time, the student continues to wrestle on, not knowing that the proctor has actually outputted; but when the proctor does have time or when these messages really become quite urgent, hopefully she will wander over to the terminal, she will call for a restart point in the program (all these restart points have to be prearranged: the curriculum team has to decide what is a reasonable restart point, a tremendous amount of detail), and she will then bring the student back to the restart point. When she brings him back a code will go onto his data indicating that he is now on the line with the student. She will stay on the line with him, giving him whatever help she thinks she can, possibly responding for him or what have you, and then at a certain point she will bring him back to some other restart point and he will come in again. The program records all the data flowing out, keeps track of every response, of every time interval and of when the proctor does come on the line in addition to the data tape indicating that she is on the line.

One nice feature about the second system (and this is not a critical comment about the first system) is that IBM has decided that rather than shipping us the product directly, they are going to send it through their product test division. One of the real problems with the current system, and I think by most standards, it is a fairly reliable system, is that we have just had too much down-time. We have a CRT, a chip projector, an audio system, a PDP-1 computer, disk file that is shared with the Physics department, and a tie in with the 79. There are just too many possibilities of down-time, and we hope that the next system will be a highly reliable system. I can only add that I think this is really one of the main requirements. You must have some assurance that your terminal gear is going to be reasonably reliable, and I am of the opinion at this point that I am much prepared to sacrifice a tremendous amount in terms of the rich system of the stability of the interaction of student with computer if that is paid for with an increase in reliability. One thing I do know is that it is almost impossible to carry out work of this sort if the equipment is up one day and down the next. These students are scheduled on a regular basis and they expect to go each day and if it becomes too haphazard it creates too many special problems.

What are the research implications from the viewpoint of psychology? We are now in a position to collect large amounts of data in a systematic fashion. My friends tell me we are collecting too much data, that we are not going to know what to do with it, and they're absolutely right. Already on the spelling drills we hardly know what to do with it. If we compute a matrix of the overall probability of a correct response and the conditional probability of a correct response given an error, and a few latency distributions we feel that we can't tolerate much more. But,obviously, there is an immense amount of data and hopefully in time we will be able to take advantage of it. However, one of the real problems, of course, is how does one use the capabilities of the system to really carry out sophisticated optimization routines? Certainly, we are not going to have much to say about long-term optimization except in the most general sense for some time. But I do think we have a fair amount to say about short-term optimization. Here I would like to call your attention to a whole series of papers and one book which deals specifically with the problem of optimization within the framework of computer-based instruction. I think it is an impressive literature and I think it is growing. What is most impressive is that psychologists are not contributing solely to the literature, but it is really a collection of psychologists, mathematicians, statisticians, and engineers who, as a group, are providing a literature in this area of optimization. I would like to call to your attention to a book by Smallwood called, The Decision Structure for Teaching Machines. He applies a dynamic programming technique to the general problem of optimizing within the framework of the computer-based environment. There are a series of papers by Deere, Karis, Suppes, Crouthers, myself and several others. Several of these papers will appear in a forthcoming issue of the Journal of Mathematical Psychology. The other papers are spread out in other sources. There is quite an interest now in the general problem of how one uses information on a subject to carry out instruction in an optimal fashion. I was quite pleased last year after some interaction with people in engineering who were teaching the course in dynamic programming. A question on their final exam, for graduate students in engineering, read something like the following:

"You are trying to teach a mathematical concept. The way the student learns this concept is described by the following learning model", and they wrote out a few equations which represent a very simple model of learning that psychologists have much investigated. And then the final exam continued, "... given this model describe the optimum procedure for instruction." This is for a group of Ph.D.'s in engineering. We are going to have our effect, not only in psychology, and in education in terms of curriculum for obvious problems in engineering systems, but also in terms of general or considerations.

Let me give you a simple example of these optimization procedures. The learning models involved in this example are totally unrealistic, and I am not trying to suggest that this is the way to proceed, but this may give you a feeling for the sorts of analyses that can be made and what it means to define a sufficient history for particular problems. Let's say that I am working on a reading curriculum and am interested in teaching the subject. I have allocated a certain amount of time, say 30 minutes. I am now already putting constraints on my optimization routine and that is why I refer to it as a short-term optimization. Let's say I have allocated 30 minutes of time to the problem of teaching 10 paired associates to the subject and the 10 paired associates are presented as follows: On my film chip projector I am going to display an object on the CRT tube, and I am going to list three words. One of those three words is going to be the word that goes with this picture, and the student's task is to probe the string and touch the word that is appropriate for the picture. I show a cat and then on the CRT I display CAT, DOG, BEAR and he uses his probe, to touch the appropriate response. If he gives me the appropriate response, over the audio system I play "That's right". If he gives me an incorrect response I say, "No, displayed on the chip projector (this is not the terminology we use) is a picture of a cat, touch the word 'cat'," and I put a little marker on the screen and then he probes the marker.

Let's say I have decided that I am going to carry out instruction on ten words in this particular fashion. How do I sequence through my ten words? As a curriculum expert or as an educator you have to say, at the end of 30 minutes what do I really want this subject to do? One possibility is that I want to maximize on the number of correct items that he is going to get in some tester. Another dimension I might want to maximize on is the speed with which he would give me the correct responses on the final test run. I might define a very elaborate criteria of maximization, but let's say that I fix on the general problem that I can maximize the number of correct responses he will give me when I run through the set of ten items on a test run at the end of the half-hour period. In order to apply our theory of instruction we have to define what criterion we are interested in maximizing on in order to find a multiple criterion which involves response times, correct response, and so forth. Let's stay with the simple criterion of generating a maximum number of correct responses at the end of the half hour in terms of a test run through the sequence. Given that information, the fact that you are constrained by the situation to present the information in the way I have described, namely a film strip projector, the possible responses reoccurring, the subject probing and your ability to tell him what is, in fact, the correct response, and then the requirement that you move on to some other item. How should one sequence the items in order to maximize performance at the end of the half hour period? It depends on the theory or learning that you subscribe to. When I say theory of learning, I don't mean theory of learning in the Hullian sense or the sense of Coleman. I mean in the much more precise sense. That is, in order to characterize this, in order to specify what is optimum, I am asking to specify in some detail the learning process which one thinks is going on. Let me present two possible models that might characterize learning. $P' (i) = (1 - \theta) P(i) + \theta$ This model will assert that every time I present the item and tell the subject that the answer is correct, the probability of his generating the correct response on the next presentation is going to be related to this probability on the preceding presentation by this equation, namely the probability on the next presentation for item "i" is going to be increased somewhat over its previous value. That is one potential description about learning incurred in this situation. Another possibility is that the probability of the correct response on item "i" on the next presentation is related to its probability to preceding presentations by the following formula: $P(i)=\overset{1}{P}(i) = 1/3$. With probability "P" and less probability "1 - P", namely this is where we assume that learning is all or nothing nature. That is, either the subject and its initial value would be a guessing probability of say a third, since we give him three alternatives. The important point here is that in this model learning occurs on a single trial in the process, in the sense that up to some point in time, some preceding number of presentations, we respond and since we have a chance model on a single trial he moves to perfect responding. You might think of these two models as providing two very extreme cases of how learning proceeds in a situation. We are arguing that each time I present the item and give it reinforcement I increase the probability of a correct response by some gradual amount. The last theory on the right side is each time I present the item and reinforce it by statement of the correct response to that item there is some probability that learning is essentially on an all-or-none basis. I might describe the first model as incremental or gradual learning process and the last model as all-or-none or insight type of learning model. Well, interestingly enough these two models prescribe quite different optimization. I am not going to justify this statement except to say that the insight model and the all-or-none model describe the following scheme.

Present your items from moment to moment as you normally would, but the sufficient history, what it is important to know regarding this particular system, is the number of correct responses the subject is giving you on a particular item since the last time it was presented he provided an error. So you are presenting your items in some point in time - Time t gamma. You have to decide what to present at time t.1 (t+1). At times t it says, "Look at all of your items and for each item at a certain sequence of the history on that item, namely, look at the decision history characterized by the following counter if you will, look at the number of correct responses the subject has given you on that item since the last error he made on that item." And then it says, "Present at time (t+1) that item which has the fewest number of correct responses since the last error." This is a simple optimization scheme, but you can see what happens. Moment by moment you are continually updating your set of counters and moment by moment you are making a decision as to what item to present next if there is sufficient history on that set of items, defined just as the count of number of correct responses since the last error. The other model says something quite different. I should preface these remarks with a few comments but I am not going to bother. The other model says "present each item equally opposite". That is, present the items in a random fashion but tend to relate the presentation equally up.

Which of these optimization schemes is the best way of carrying out instructions? That becomes an empirical question, in fact, this becomes a very interesting way of testing models of learning. Traditionally, the learning theorist developed a model for learning and he supplies data collected in a standard experimental situation. It has been intriguing to me that as I have started to look at some of these problems of optimization, namely what are the optimization schedules implied by certain learning models, often one hardly needs to even take some of the models that have been developed in the laboratory for testing. One can just simply say, "let's look at the model, not in terms of the standard experimental procedure but in terms of what its implications are for optimization," and then often you can see the implications that can be rejected at first hand. For example, many of the models in the area of discrimination learning do quite a good job of caring for data, but when you look at the optimization implications they argue that you could present all of one stimulus first and then all of the other stimuli and this, as any experimenter knows, in most cases is not the way to proceed.

That gives you an example of what I think a model of instruction would look like. This is a particularly simple one. When one goes into models that are somewhat richer than those two, one gets into much more elaborate schemes, and much more elaborate computations than are implied in this one. For example, what is a natural way of progressing from this point if you assume that a given subject is best described by a model that is really a hybrid of these models? In some subjects it might be heavy on the value "theta", in some heavy on the value "C" and then your problem in the optimization routine would on the initial trials, be how to estimate the values of "theta" and "C" for that subject and then to branch off or move into an optimization procedure if the linear one or the all-or-none one, tended to be optimal for that subject. As soon as you get into schemes of that sort you get into much more elaborate computation and again, these computations that can be done quite simply on the computer and are incorporated into our instructional program, in several places. Now, the next comment might be, "Well, that is terribly limited if you think you can really model learning in a situation like this." My comment here is, I do think we can model small hunks of learning, certainly in the reading curriculum. We can give a good model analysis for half-hour or 45 minute sequences and I think what we are going to be doing is modeling a whole series of these. Maybe the 40 macros indicate how many models we are going to come up with when it all progresses further. But this is not my view of the theory of instruction. All I can say is I think that at this stage in time we can develop some of these models with a lot of detail, even models that don't make a great deal of practical sense, and start to get a feel for some of the optimization implications and for how one utilizes history to define this notion of a sufficient history. I think this sort of analysis is going to provide people with a lot of insight in terms of developing the curriculum materials on a strictly practical basis, in the same sense that the mathematical economist really applies his mathematical models and details in a real life situation. But, nevertheless, the models are suggestive as to how to stimulate or even develop a policy even when one can't display its implications in mathematical detail.

Let me comment with a few general critical remarks. The problem of curriculum development, I think, is one of the major problems. There are real computer science developments involved in this whole area, especially moving towards what I mentioned before in the dialogue system, but I do not think that it is going to be sufficient to turn over the problem of curriculum development to industry. For one thing, I think one danger that can occur in the rapid development of this area is for industry to think that they could put together a package that would provide the hardware and the systems program and also the curriculum program. I think this whole order of curriculum development is an entirely new concept.

It now has a much deeper sort of development. One can't possibly do it with one or two people. It requires a lot of care. Everything has to be planned in such complete detail that I think serious curriculum development takes years. For example, our curriculum development in reading has taken roughly two years and it will take another six months before we are on the air. And I think we move fairly rapidly, although I think it could be done more rapidly if we started agin. If one is planning to develop materials one has to set aside a fair amount of time for curriculum development.

I am sometimes hardpressed to know what to say when people ask me "What's the cost factor here?" I notice Karl Zinn cited $100.00 an hour as a figure for hard-line instruction. ZINN: It tends to cost over this amount. ATKINSON: Let me give you the cost of our operating budget as we see it. We are going to be running 16 terminals on a six hour basis, including the cost for developing curriculums, the cost of the system, rental costs, and what have you. Amortizing this over a 10 year base (and I am not sure if that is a reasonable base for computer-based system, possibly not), my estimate is roughly $1.00 an hour for our system that will be in operation next fall. If we cover the first two years of initial reading in 200 lessons, and each lesson runs roughly less than 1 hour, I am arguing that I can carry out the total instruction in initial reading roughly at the cost of $200.00. That sounds like a fantastically low figure. ZINN: Would you clarify how much curriculum development is included?

ATKINSON: The full package, right from the initial writing of the material. ZINN: All staff and all supporting staff? ATKINSON: Yes, over 10 years. There is no allowance in there for treating the data once we have it, or for revisions and so forth. Granted, I tended to cut corners in terms of making that estimate, but what I am saying is a dollar an hour is getting the research implications, for getting teacher modifications and so forth. That is, next June, supposedly we will go on the air full time. Up to that point the rental cost of the computer for 10 years averages out to about a dollar an hour. SELFRIDGE: The film costs about a quarter of a million dollars? ATKINSON: My computation is actually based on a nine-hour school day, assuming that when we are in full operation we will also be carrying on instruction to adults in remedial reading. Let me add one other thing, I am basing it on a 12-month year, too. Let me try to recover those figures. FELDMAN: The question is whether or not this system is better than a teacher that you can hire for $16.00 an hour or two teachers for $8.00. ATKINSON: The point is that there are costs on these matters. Void that comment- I really don't want to get into the problem of evaluating systems. I was going to finish with some general remarks on the humanist tradition. GERARD: Thank you very much, Dick. I can't think of a better opening presentation for the conference and it was a splendid job. The point that struck me particularly, aside from the cost one which immediately alerted much reaction, is your own example of the use of this facility for research in education. The work you told about on maximizing, though it was primarily the psychology of learning, was splendid research on education and the process of teaching. I was also very much impressed by Dick's almost emotional emphasis on the huge variation in the individual progress. Since we are faced with this problem of slow learners, this may be the essential mode of getting at them. Some of you surely saw the article in Science, I think last week, on the psychotic dialogue between the computer and medical students in teaching medical diagnosis, a most impressive example of communication. SELFRIDGE: Weitzenbaum and Gilbert. GERARD: Thank you. This leads me to another point that Dick emphasized to generate discussion. How much richness must you sacrifice for reliability? I see a major discussion going around that problem. Finally, I remind you in raising your own questions that we have around the table here very major representatives of users and producers of the resources, and questions from one group to the other, what you want us to do for you or will you make this for us, this would be especially profitable. FLOOD: I would like some discussion on retention from empirical work as opposed to the immediate task of number of fractured processes. SELFRIDGE: Correction for the record. The primary program which you attributed to Colby was an adaptation of fundamental work done by Joe Weitzenbaum. His name should be the one primarily recognized for that work. Add Gilbert's name to that. Isn't it correct that Weitzenbaum did it mainly to demonstrate that computers can interact in a conversational load? SELFRIDGE: I would like to discuss what the goals of teachers are. The implication is that the teacher is merely trying to run "generating a maximum number of responses by the period". I would like to discuss what is a good teacher in fact trying to accomplish? It seems to me that she is trying to get several things done at once and many of these things are not being brought out. ATKINSON: I agree. What I am saying is that whenever one specifies a model of instruction it requires specifying what criteria you optimize on. I gave an example of one set of criteria, and said that was an unsatisfactory one.

BARRUTIA: I want to be careful that we think in terms of the linguistic theory of language learning and more prevalent theories of language learning in discussing any program which has to do with language, whether it is written, spelling, English or a foreign language. Many times I often wonder if this is taken into consideration in the programs. ATKINSON: I hope to come back to that. CORRIGAN: I would like to have some discussion on this total curriculum concept, looking more thoroughly into the details of the process of curriculum development in relation to proposed strategy, to design and planning, and some specification of that and the theory of construction which is evolving. KOPSTEIN: In that connection I would like to propose what I think is a very grand topic for further consideration. This is, what comes first, not in a chicken and egg sense, among the triad of instruction, hardware and software. Obviously, the three are interrelated and apt to be developed somehow in phase, but conceptually what has to come first if the question is asked, "Well, what do you want, what shall we build for you?" I think I am betraying my bias. It seems to me that the theory of instruction comes first, that out of this has to grow the hardware and the software. GRUBB: I think it would be appropriate to discuss environmental configurations to students at terminals and what ratio, for example, might exist between the tutorial devices and the student. Here it might be appropriate to discuss a recent study on which some of us compared student interaction at the terminal. It raised two questions, first, optimization procedures: what happens to air rate, time and so forth. Secondly, the question of effectiveness was raised. I think both of those questions might be dealt with. STARKWEATHER: It might be interesting to look at this notion of short-term and long-term optimization from a somewhat different standpoint. If you think of the terminal operation as imitating or playing the role of a tutor or one partner in dialogue, you can then think of the short-term and long-term optimization procedure as being analogous to short-term and long-term memories and activities of this dialogue partner. This is a particularly useful point of view, I think, when one gets into the area of trying to carry out this richer dialogue interaction. It becomes increasingly interesting to me, at least what characteristics of this situation lead to the appearance of intelligence and understanding on the part of his partner being played by the computer. I think these systems all tend to start with emphasis on short-term memory because this is the easier aspect of it, but this appearance of understanding and dialogue ability doesn't begin to develop very fully until one has increasing development of the long-term memory. This becomes more and more important in making understandable dialogue. LICKLIDER: Is the practical optimization procedure limited to the Drill and Practice level or can it be carried on into the higher levels as far as the Dialogue process you mentioned? Second, where is the bottleneck or what is the limiting process? From what I have seen so far, I strongly suspect that it is the actual learning by the student or his trying to hunt and peck the characters on the typewriter or finding that place to push where the light is.

ZINN: I want to call attention to two other areas. I don't think they are as important as you mentioned but they shouldn't be left out. One is, the on-line aids for calculation or design or whatever which perhaps can't be distinguished as actual tools of learning might work later but in any case, they plan a very important role in instruction. Another is the extension of these aids to a classroom teacher if this is the desirable mode in the sense of an electronic blackboard, an elaborate blackboard device. The third thing I want to say is to call your attention to two lists in the back of a survey paper. One is a list of projects which is helpful for reference. The other is a list of materials that I have information about which have been prepared for computer construction systems.

GERARD: We will have a quick review of the situation. Karl Zinn and I have attempted to structure these many points into three groups. If you don't like our groups, you may be quite right, but perhaps they will give some coherency to the discussion. We suggest that maybe you express yourselves through them in the order in which I give them to you. First, perhaps least interesting but most tangible, some of the technical problems that have come up; reliability, capacity and richness of the facilities, richness of the program, cost, question of terminal patterns, not getting into the hardware as such but the use of them in relation to the learning situation, and the problem of interfacing for various kinds of learners of the material.

Secondly, what we call the psychology of learning and the strategy of teaching. I have decided to separate out such questions as "What is precise or problematic in the learning process"; the question of language learning; retention; program design in relation to theories; can one optimize at the level of dialogue interaction?

A particular point that was mentioned during the break, the desirability or effectiveness of using young children not merely as learners but as programmers themselves, leads on to the third major topic, the uses and validation which could perhaps be divided into the purposes and the degree of achievement in the total learning situation. What about the total curriculum long-range problem? What about the role of the teacher? What about the use of the resources in particular situations? What about laboratory simulation in presenting problems and presenting the total curriculum? BARRUTIA: Could I start with a question? I am very much interested in the images being used for language learning in order to do away with giving English equivalencies; I have three questions. One is about transference of video tape from one device to the other, problems of making our own program on CRT. The other, probably more important, is, can the devices, because they move so fast, be scanned or searched for branching that would occur way back at the end, in case you have some other new phase that had to be included at the end of the program? Or would this have to be done with a very complicated editing process to be inserted in the center? If it does have to be inserted, edited and cut and so forth, can video tape be rapidly scanned? ATKINSON: I could talk about video tape and so forth but there are people here who can say more about it. Let me say that I would like to see a richer display scope than we have. I think our display scope is fairly rich in the sense that we can display things and move a pointer in time with the audio so it is much like a bouncing ball in the cartoon. The other capability is tied with the audio moving the pointer along to point to a point in the display. Of course we have a whole dictionary of special symbols in the outfit, any one of which can be displayed. We have constructed some very fancy visual displays. I am very much interested in this new scope that IBM is putting out -- the 2250 -- and I am especially interested in some of the work in geometry where one can actually rotate figures on the display scope and so forth. This would be a very desirable property. When we first started talking about this there weren't any manufacturers to go very far in terms of detailed discussion. Not more than two years ago we were actually talking about a system where we would simply have little display devices that could generate characters via a projection mode, so the CRT was a big thing in our conception. LAMBE: Dick, I just want to pick up the point that you make/because I want to remind you of something else that you said. That is that reliability was a very, very important issue in actual practice. To what extent do you find in your operation that reliability and a rich display scope, for example, might be in conflict at this stage? ATKINSON: I have no way of estimating that. A year ago I would have been much more optimistic and if a manufacturer had said, "Look, we can do it for you," I would have believed him there on the spot. I asked someone from the Department of Defense, "How do you decide whether a manufacturer can really do what he claims because the claims are really not ever checked out in the final analysis; never have been in business?" I was fairly naive about these things. He said, "You never order from anyone. You never believe their claims unless they have delivered a similar system. If they have never delivered a system like the one that you are requesting, don't believe them." LICKLIDER: I would like to go back to an experience three or four years ago with BET1 and its oscilloscope and say that there was never any trouble with its display tube or the light pen; anything electronic continues to run day after day. The trouble is the electro-mechanical equipment. So you get better reliability when you go to scope, not worse. I think this is borne out by experience; it was personal experience there. BARRUTIA: Does that mean that we will get more reliability from a video tape than from a film because there is less mechanical function? ATKINSON: We are not using video tape. LAMBE: I would just like to ask Dr. Licklider if you would regard the important ingredient to get out of the system the typewriter? It strikes me as electro-mechanical. LICKLIDER: In my experience typewriters have caused a large amount of the total breakdown, but after you get used to having extra ones around and get good at getting them into position, it keeps the show rolling. Just be sure you have a few extras. STOLUROW: Dick, I would like to ask you whether using a kind of light generator arrangement instead of a standard keyboard might be a better station arrangement? Most of the existing systems which have a response unit employ a mechanical one, except for a light pen, but they still provide for the manual response. Now, this would suggest that you might want a photocell or some light pen arrangement instead of a keyboard and eliminate the keyboard entirely. GRUBB: I was going to comment that we should distinguish between the typewriter and some kind of mechanical-electro device keyboard. The typewriter keyboard might still be a very stable and reliable keyboard entry device, but you could use a key as an output and thereby have a very fast and quiet output device. Although you lack the hard copy you still have a typewriter input that is fairly reliable and familiar. SELFRIDGE: Typewriter machines are, in fact, very reliable. We have very little trouble with the Selectrics. It is a new gadget and you expect to. The teletype machine has never failed in service. The service has kept it up. I think it is only a matter of time before typewriters mechanically become as reliable as we think about the electronic equipment. BLAKESLEY: Is there a problem regarding maintenance? Back-up time? ATKINSON: You mean in our current system? We have never had any trouble with our teletypes. There are all sorts of special problems and a certain amount of the gear has never worked properly from initial delivery. DAVIES: I would like to comment that I think there are some basically different ways in which computers can be used in the educational process, in the learning process, in addition to the completely structured and programmed approaches that have been discussed this morning. For instance, there is a little company very near here called Precision Control, Inc.. Bob Herrmann, the President of this company, was telling me the other day that they have devised a little computer and made it available, I believe, to the University of California at Davis in the San Juan school system. The idea here is to just put this thing in a room and let children learn how to manipulate it. It is a very primitive kind of computer and the student has to learn very fundamental things in order to get it to do anything. He has to learn how to construct a binary addition and so forth. Apparently this has had a very stimulating effect in some of the experiments that they have performed. They tried an experiment in which they took 27 students who had been specifically selected as being drop-out candidates and exposed them to this gadget for over a year's time. The results that he described were that about 24 of these kids went to college. Two of them joined the Army and one of them got a job. The people who were involved in this program were very enthusiastic and felt that this computer made a major contribution in this respect. Now, there wasn't any program associated or curriculum assigned as I understand it. It was just letting the student investigate this thing and be stimulated by it, and discover that he could model certain theoretical concepts which maybe other parts of the school system were trying to teach him but which just never interested him very much because he didn't have any way to associate them with something real. This ability to manipulate and form physical models turned out to be extremely stimulating to his whole intellectual curosity. I think that there is a whole spectrum of this kind of thing that hasn't been touched upon.

RIESER: It is very pertinent to me to keep in mind the possibility that in addition to using computers to instruct children in a most formal trend there is important creative opportunity. I wouldn't say it was children construction computers, although I wouldn't rule that out. Consider the experience that we have had thus far, which is that programming itself, provides elementary or high school children computer interface. This has been most rewarding. It could be that our problem is teaching children computing when school lets out. It certainly is clear that children early in life can do things of a logical sort without the humanistic experience. I think it would be quite important to see what opportunities could be injected for a creative role for children in this kind of endeavor. It doesn't depend a lot on the language of the computer that we have, but I would become worried if we essentially develop merely an efficient way for storing information in the human brain through eyes and ears without trying to promote the creative work by the children. I can give one other example. At the __________ Corporation we are beginning to do some work on the kind of visual laboratory with program work which will initially be aimed at higher level, colleges, etc.. I think perhaps the technique can be extended and work here will go into such things as design of visual networks and pulling out trend and this kind of thing. STOLUROW: I simply want to indicate that we have been trying to conceptualize the problem of getting to the so-called discovery process and the imposed instructional structure which is represented by the program construction and education in general, and then derive from this some studies which would help us make with this some of the problems that seem to emerge as separate areas of concern. One of these is the kind of learning situation wherein the individual has the specified set of choices and has to make a decision about problems. We have looked at this kind of situation because we can render it into an information analysis and we can determine whether there is efficiency achieved by imposing a structure close to the one which is generated by the learner. One of the problems in general in getting data on this basic question that has been raised is, How do you know when you open up an environment, so the speak, to allow the student to create? How do you know whether, in fact, he is operating at what might be considered an important or useful way as far as his own development is concerned? These examples of some individual and isolated cases suggest that one is capitalizing on the discovery process with something that is about ready to take place rather than something that could be part of a curriculum or part of an adjustment plan. The data so far suggests that individuals don't necessarily make decisions which are to their own best interest. They operate at a substantially lower level of efficiency. They are aware when we ask them what kinds of strategies are used; they report they are more aware of the strategy than they are of the output. This seems, of course, a healthy direction of movement, but not sufficient. This is an important area. I think we should be careful not to be led astray by some dramatic few cases that seem to indicate that all you have to do to solve education's problem is to provide a new kind of toy for the kid to play with, but let him recreate a geometry or whatever. SELFRIDGE: It appears that what Dr. Atkinson considers necessary in terminals is extremely expensive and unavailable in any present system. The terminals you are talking about, in fact, today cost about $50,000. You may get it down to $25,000 in two years but this means that unless you do it with a hefty grant on an experimental basis you are not going to get any widespread use. It may well be that you can get a very nice terminal for $500. You can buy a heavy-duty teletype machine complete for about $1,000. What kind of things can, in fact, be done here? We might even use the kind of display that is kept on a flat substance we are printing on a screen which might be put in a stack, a number that is convenient for the student to use, which he might refer to. He might turn the pages instead of having a CRT. In some cases this might do as well. I think my emphasis is that the kind of service you want to provide needn't be enormously great to be useful. ATKINSON: That is why I was trying to emphasize the notion of Drill and Practice. Essentially our Drill and Practice system in mathematics drill is nothing more than a teletype terminal. It is a teletype terminal with an audio output from the Westinghouse random acess audio system. I think terminals of that sort can have a really profound effect in the early grades. One could really conceive of covering the whole San Francisco or Bay area with terminals of that sort at a reasonable expense and have a great effect on arithmetic skills and the language arts skills in these grades. SELFRIDGE: Why did you ever think you needed something as big as the ambitious one? ATKINSON: I think that a system like that has a limited capacity in the sense of the curriculum material it can handle. For example, I don't think I can carry on reading instruction at that type of terminal unit. One thing which worries me is that we are depending on the teacher to interact too closely with terminal units. I am fearful about a curriculum that builds around the teacher and expects the teacher to provide a contribution to the educational process in conjunction with the computer-based system. This is sort of a strong comment. It relates to these two comments about imitation in the classroom. I like to think of the system that is almost teacher independent. The Drill and Practice System is teacher-independent in the sense that if the teacher wants to utilize information, she can. If she ignores it, it still can have an effect on the student running through the machine. The tutorial system is teacher-independent in the sense that if she does an absolutely terrible job, the system is still constructed around the concept that it will provide some minimal level of proficiency in the area of instruction. I am very worried about depending too heavily on the teacher at this point in terms of supplementing these activities. That is my view of the problems we will face in instruction in the early grades. I hate to depend on teacher education before any of these innovations can occur. GERARD: There was a lot of discussion on these problems at the physics symposium, and much experimentation with it early this summer. Lambe has his hand up and I hope that whatever else he wants to say he will throw in anything else that is relevant. LAMBE: It seems that one could go with computers in the direction of much more tightly structuring and organizing instructional experience so that it was indeed independent of the teacher. Another way, somewhat opposite that, is that you could use the computer as an aid to loosen up the whole structure. The general line of development that we have taken, for example, in developing sequences in optics this summer, has been to use the computer rather in that way to fit the college level situation much better. Do you stress your point of view so strongly because of difficulties inherent in the teacher situation or is this a view about instruction as a whole? ATKINSON: You must realize that I must cross all of my comments from the record. I am in an absolutely indefensible situation on this. It has just been my experience that when one gets into the schools even with competent teachers, knowing the problems, the heavily leaning on the teachers in a situation of this sort just creates too many problems. College instruction may be entirely a separate issue. Even in our total curriculum emphasis, half an hour of reading and half an hour of mathematics a day, the rest of the day, the other five hours, is under the teachers' control. That figure may seem a little small, but look at some of the literature on the amount of time spent on instruction, not only individualized instruction, but where the student is interacting with the teacher either in a group or individualized or what have you in the early grades. There are very few people who will say it is as high as 15 percent of the school day. The low estimates run around four percent and five percent.

Certainly a more reasonable estimate is that ten percent of the day is involved in instruction, as opposed to many other activities. You are really somewhere at the range that schools are organized to handle at this point, and so an hour of instruction at one of these terminals is just a fantastic amount of instruction. GERARD: Are there any comparable figures for college teachers? ATKINSON: (laughing) I can cite my own. GERARD: I am not talking about fraction of teacher's time, interaction time that goes to instruction. ATKINSON: Well, by those figures, an hour of lecture would be part of the 15 percent. GRUBB: I think very little has been said about symbol tests, for example, legibility for readability. The noise factor, and a number of things which bear very heavily on the kind of terminal one is going to have in a CAI medium. For example, I know of only one teleprocess terminal that has upper and lower case. A number of studies were done in the 30's which compared reading speed when one only had upper case and this cut reading speed down by a factor of two, I think. When one only had messages in upper case, this would be a kind of telegram. So it seems to me that if one is going to have a cheaper terminal one pays for this in terms of student's reading speed at the terminal. If we wish to call in other courses for this memory bank, such as courses in mathematics, foreign language, we usually run into a whole host of symbol problems. Typewriters are noisy, no matter what kind they are. When you have more than two or three side by side you have a really intolerable noise level in a study room. You are immediately faced with the tremendous problem of the computer typing out or the student typing in reply. Some of my own practical observations where people have used these typewriters in this medium is that after they scanned the student's typeout and used it for their own research purposes it was thrown into the wastebasket. I believe the hard copy output has not been very useful, in terms of the research. I think another point which bears on the kind of terminal one has in the situation is a perhaps more subtle point, which concerns one's philosophy about CAI. Are we merely automating programmed instruction or are we really thinking of perhaps the next stage, which may come very quickly, and that stage is the dialogue? I can think of those terms very quickly, yet what about the dialogue where the student is on-line; let's say where the computer wants to show him a graphic output, for example, to float some lines. It seems to me then that these are very integral points which bear on the kind of terminal and CAI configuration. I think there is really a great deal more than just a cost factor at this point in the program. ATKINSON: I am prone to reinforce Selfridge's point. I think that much can be done over a wide range of application with much less elaborate gear than I have talked about in terms of our tutorial system. That's why I like to reinforce this idea that much research can be done on what I call the Drill and Practice System, and I can see those as being potential systems for wide-scale application in four or five years. Developments continue to be promising and also quite reasonable in cost.

MITZEL: I want to support Atkinson's statement about the amount of actual teaching that goes on in the classroom. The work we did in New York a few years ago has been further verified by recent work by a different investigator. If you classify what teachers say in the classroom according to their problem structure statements, controlling kinds of statements, and others that you can identify, you get somewhere around 10 to 12 percent of problem structure and statements. These are the kinds of statements that you can classify as leading students to increase their understanding or their active focus on content. I agree that teaching as we see it today is not really very efficient, and that the time that children spend in school is not focused on learning.

RIESER: I am reminded that Zacharias early in the innovation game established the grade teacher-proof and I think perhaps it is necessary for the short run. I don't think we will ever create the kind of environmental change we have in mind if we don't complement our short-run idea about teacher-proof with a long-run kind which deals with these changes not as merely supplement to what the teacher does but considers how he or she is truly read into the system. There aren't many representatives here from teacher's colleges, but I think that one of our big problems in these changes is actually getting them into the system, involving the whole educational community instead of suggesting that it is all right what happens the other five hours, this is going to be a significant half hour or hour of individual instruction.

GERARD: Do I correctly paraphrase you in saying that you are advocating not the use of the teacher as the primary continuity agent, with the computer as tutorial thrown in as the supplement, but the reverse?

REISLER: I don't mean to say that. I thought we were tending to ignore the role of the teacher. First of all, for the most part it is effective. Secondly, we want to make these materials teacher-proof. I don't see that has worked so well in the past. As long as we are dwelling on education at this level, the teaching community and the whole supervisory community and so forth somehow has to be built into this in the long run, although I accept your observation for the short run.

ATKINSON: I think the schools in the country take the attitude that I expressed. Obviously you are very much concerned about the teacher's attitude, and we are this year carrying on a teacher training program where we bring in about 10 people twice a week. This last week their families came in the evening to play around with the computers and so forth. They have to be brought in on an intimate basis. All I am saying is that there are always going to be a couple of bad apples, and I hate to depend on the system operating at the level of the lowest teacher.

GERARD: I should remind us that the topic of this conference is Computers and Universities, not computers and education in total. Nonetheless, these problems are relevant. I know many people are taking the position that, not at the present but in the forseeable future, one will greatly improve the total impact or thrust of the curriculum or of a given course, if the continuity and conceptualization is not entrusted as much to the individual leader of the course and interaction as it is to a more wise, more experienced aspect of greater teachers who have built it into the total program.

BRIGHT: Talking about interfaces, it turns out that fortunately some of the concepts here, namely reliability and cost, go hand in hand in the long run, as things become simpler, they become more reliable and lower in cost. The terminal we have selected as having the best long-term potential in all of these categories involves a typewriter keyboard, a cathode ray display, and a light pencil. These are some of the ones talked about before. We arrived at this from a number of points of view. One, we thought that we could not tolerate a typewriter because of a reliability problem, particularly if you have children in the class who constantly are trying to jam it. Also there is another aspect. Actually the cathode ray display is a multi-purpose device, it displays the characters the students type, it displays the textbook output from the computer, and it can also be used for pictorial displays where you combine several things in one device and thus reduce cost. As a matter of fact, we feel that the cathode ray display can be made cheaper than a typewriter. It leads to one other thing, though, if you talk about using a console such as the one we are talking about. I might mention the typewriter keyboard before we pass it. Someone asked if we could make something more reliable in an electronic device that the kids point to or use a light pencil or something. We definitely could make something more reliable and cheaper. We feel that probably one of the important side effects of this is the student learns how to type. For this reason we should keep the standard typewriter keyboard because it probably has a very valuable educational function. If you talk about using a console such as the one I described, where you are using a cathode ray display for displaying characters locally and from the computer on hand, displaying pictorial information on the cathode ray display, you get to the point at which you don't think you can use them remotely. The information rate to the transformation consoles is simply too high. This has affected our entire concept of the structure. We visualize the economical system as one with a small local computer servicing about 100 of these consoles simultaneously, and on this kind of basis I think it makes sense. On this type of console you just can't get the information rate that you need and the economical method needed for remote operation. So the basic decision on the console type and what you want to do with it also, interestingly enough, has direct impact upon the entire system organization.

GERARD: Licklider, I hope we can move back towards the psychological factors now and the hardware ones, which we can return to.

LICKLIDER: Let me just briefly point out that I think Grubb's statements effectively counter all of the results of bridge burning. The typewriter is useful only if the student can type. If he can't type it reduces to a small multiple choice thing where he uses only a few keys. If he persists in typing, it makes the process so slow that it equals a book or ordinary teaching. Grubb talked about capital letters. These are almost merciful because these type so slowly that you can't read fast anyway. But it seems to me to be certainly a reversion of what we are trying to do, put up with just capital letters, not lower case, and this slow peck, peck, peck typing out of the message. I think it is true, as Bright says, that oscilloscopes are not intrinsically more...they are more expensive than typewriter-like devices. If that is true, I think our job is to find out what type of console there ought to be and then learn how to mass produce such a console, such as the television set that you can get for $88.98.

GERARD: I hope this will very much be in the center of the afternoon.

KOPSTEIN: Might we specifically charge the afternoon session? Perhaps even between now and then a few hard facts could be assembled on cost, capabilities of current equipment.

GERARD: Grubb is the speaker. Will you consider yourself charged to assemble these figures on costs?

KOPSTEIN: I would like to come back to a point that was briefly touched on. I think it is in the psychological realm, and this is the question of the efficiency of teaching. How much effective teaching goes on in an hour, or in a six hour day in school? It is probably true that only a relatively small percentage of that time could be identified as actually effective teaching ground. Truly, the behaviorial capabilities of the subject students are being modified in some real way. On the other hand I see a reverse problem here. This assumes that computer based instruction is vastly more efficient. How much of this can an individual take per day? There are suggestions and these come from my own observation, mainly in programmed instruction which also partakes of the more efficient character. People just can't take this for eight hours a day. They can take a lecture for eight hours a day because the lecturer will, I suppose in a sense, say something that is relevant.

GERARD: Who can? (Laughter)

KOPSTEIN: I said I suppose. Well, I think of the inefficient character of the lecture which is larded with ancient jokes and so on. There is a reason for this. On my part at least, there is a suspicion that any time something significant gets said the listener, the learner, the student, whatever you want to call him, probably operates on this information overtly and maybe he partly turns off what is going on at the moment. He probably in some overt ways seeks to link this to previously stored information that he has, or he does something with it. I am pretty sure of that because of introspection about my own activities, and if he did this in a more rigorous way fundamentally, I have a great faith that he would find essentially the same thing. The point is, if you can increase the efficiency of teaching, can you really expect to load an individual for prhaps more than an hour a day with this concentrated dose and then let him go to play or reflect on what has taken place; or can you carry this on in long stretches? I suspect that this cannot be done.

STOLUROW: There is one implication to what has been said that I would want to respond to. That is that CAI is different from reflection. My feeling is that an appropriately developed (line?) program should involve our mind reflection, not outline reflection, and I think this is an important distinction between the potentiality of CAI and what we have known in the past as programmed instruction.

GERARD: Another point that was not made is that perhaps one doesn't need the equivalent length of time for the equivalent achievement. Maybe the total educational experience can be condensed, at least up to the same goals in a much shorter time. Also, one might have an enrichment of the output so that the computer doesn't merely type out, "Good, that's the right answer," but when it is really important it should ring a bell or something.

MILLER: In regard to the comments on teacher's proofness of CAI, I would like to point out that there are probably two classes of reasons why we take CAI seriously. One is because in some way it is a more efficient type of learning and the presentation is more individualized. The interactions are more active and the programming optimizes things more precisely. There have been a number of such points made. The other is perhaps that it is possible for CAI to be more intelligent than the average teacher in grade school, or more informed and better educated, and from the point of view of the national scene this is a very important aspect. When you think about a grade school in Alabama or a high school at the Mexican border, it may be that those communities just don't have the resources in teacher manpower, or the financial resources, or the willingness to support the education of teachers, to the point that they can keep up with the developments of the education process and secondary education across the country. We have been subjected in recent years to the accelerated mathematics, and in high school situations in many parts of the country the teachers were simply behind the student in ability to keep up with the material. Therefore it seems to me extraordinarily important that, regardless of the diplomatic problems which Dick Atkinson through his experiences has seen important and which obviously are important -- how you are going to deal with these matters and obtain the ego of the school board and so on -- it is certainly going to be essential for us to attempt to develop systems that are sufficiently teacher-proof that they can be used in schools where students know more than the teachers themselves do. Otherwise we won't have the assault to jump forward in education that we hope for in the country that has been retarded in secondary educations. These machines should be so teacher-proof that they are segregation-proof.

ATKINSON: I would like to remark on the teacher-proof. It is teacher-proof in the instructional sense and it is also teacher-proof in the mechanical sense. I have the feeling that the reason that audio aids are not really much used in schools is that the films and reels and so forth are too complicated to use. I think one important feature of a computer-based terminal is that the teacher doesn't have to learn how to load anything. It is an operation that is like turning on your TV set. If it gets more complicated than that you are in trouble.

MILLER: I would hate to think that we would make the teacher be a mechanic but perhaps we are going to have to teach teachers to do something about preparation of these technologies. Either that or, as Dr. Lambe was suggesting, we teach them how to type. We may also have to teach students how to construct and repair their own computers.

ATKINSON: Let me just stress that point. It is one thing for the student to come on the line and type his name in, and another thing for a student to be assigned a terminal, and for the teacher to load some film strips, and for the teacher to load some audio and find out where he was the previous day, and start him up on that and what have you. The more this is done by human beings at the site the more problems you are going to have. It has been our experience that anything less than almost complete automation is going to create complete chaos in the school.

GERARD: I would invite some discussion of the third general topic which includes a half dozen key items. We seem to be hitting at just what is the role of the teacher.

SELFRIDGE: I have some specific comments on some of these remarks. You have to struggle to get fiscal allocation. For example, in Europe all the telegraph offices use only lower case. I quite agree that this lower case is what everybody should have. In the question of key displays Dr. Bright's remarks were made by some friends of mine ten years ago. Very good friends of mine, as Dr. Licklider well knows, advocated building a very cheap laboratory computer which he said would cost $15,000.00 It was called LINK. The current price of LINK is, I think, $48,000. Well, these things never get as cheap as you like. I deplore this, and I am as fanatic and dreamful as the next man. CRT's will not be as cheap as television sets for a very long time, like ten years. I don't think we have time. We are at this conference today because we don't have 10 years to help correct or improve education, and the topic we are talking here about is computers and universities. I think we must find time now and find ways now to do what we can do now and not wait for cheap displays.

GERARD: This is a very important topic to examine. There is debatability on whether you push ahead with inadequate resources, either technical or organizational or anything else. It has given enough people enough bad experiences to set back the whole development. I think this question of what are the thresholds of a satisfactory state of the art to introduce people to the different levels may be very important in the discussion.

SELFRIDGE: I absolutely agree and I presume this is why we are doing research and not widespread use. We talk about widespread use, but our job is to find out how to do it right, not, in fact, to get every hamlet full of teletype machines.

ATKINSON: I agree that our effort is a research effort, but I would not want to carry on a research effort in reading, for example, with 12 students. There is a number factor here. I am just not going to be happy with my understanding of computer-based instruction on a two-year basis unless I have about 100 students on a day-to-day basis. We have had our chance with six students at a time and it is not quite enough data.

SELFRIDGE: I have one question which you touched on a little bit, and which if you have time I would like to hear more about. This is the courses for teachers. The teachers have to have the courses. I presume the content of these courses is more than the content of courses the students take. Teachers waste quite a lot of their time now going through teacher's colleges. Presumably what they learn from you about planning computers and the techniques has some real content which they don't get in touch with. Quietly, over a drink, I will tell you what I think a Ph.D. in education should require.

GERARD: Maybe we can get that out in a session.

LICKLIDER: Going back to the mechanical proofs, I want to remind you of an experiment last year, I think, with teaching machines, computer-aided learning. The only students who learned much were those whose machines broke down, and who then participated in the repair. But, the point I am more interested in making goes back to Felix Kopstein's discussion of what would it be like to learn intensively. My intuition disagrees with you a little bit, Felix. The only experience I think is comparable is experience in extensive language courses. As I understand it from a few people who have been down to the school at Monterey and a few others, it is a very enjoyable, almost exhilarating experience to live in an environment that is very responsive for eight, ten, twelve hours a day for several weeks at a time. They have never forgotten it, and it is a very efficient learning experience.

KOPSTEIN: May I just comment on this and say that this is perhaps a slightly different order. Here we are talking about a highly responsive environment in which, in effect, the student takes the lead and makes it the slave to his desires rather than the other way around, where the equipment for the program inside the equipment dominates the student. I think in terms of the second category where the students respond to the program. My own experience in this kind of a situation as well as that of people whom I have talked with in that situation, is that you can't take it for very long. Then you've got to just relax and to act reflectively. In acting reflectively you may want to pose questions; maybe this is the time to go into a conversational system, a dialogue, but in the situation in which you are being pounded with new information, I think there is only so much you can take in at one time.

GERARD: Several of these comments are in line with the more general statements that the further one can move in transferring the initiative from the machinery to the learner, whether the machinery is a living teacher or a piece of equipment, the more successful the outcome, the more it means to the learner, the more he actually does get a creative experience. This suggests to me that some attention might be paid to the matter of motivation in a more mechanical situation. How much the teacher as a human being has to be found as a heroic figure, as a friend, as a counselor, or whatever else, is something I hope we will take a few moments on.

STOLUROW: The conception of the teacher which I think is pervading a lot of our thinking is the notion of the teacher in the present configuration of the classroom. With CAI I think we really should move on to the notion of individualized and true tutorial instruction. When one moves to the position, then I think it becomes quite apparent that the CAI system can do things which a human teacher cannot do. For example, the system can individualize the instruction by taking into account characteristics of the learner such as personality and aptitude, both on an individualized basis and on a dynamic basis in the sense of making different decisions at different points in the program where, in fact, two different students are making the same response to a display. This kind of individualization is not only possible but, I think, it represents a dimension of CAI which we need to give more attention to.

BRIGHT: I want to make two comments here. I would like to make a suggestion to you on bringing up this next topic of the speaker's role. In the last year or so, as I have gotten more and more involved in education, I have recognized some of the tremendous educational problems in the elementary and secondary school. I have been convinced that the number one educational problem is the undergraduate university. I was going to ask specifically in the line with the topic here if we could have some discussion on the teacher's role on using computerized instruction in universities and how it would go across.

Second, I might take issue with one of Dick's implications, I am quite sure Grubb would too. That is that the companies are interested primarily in hardware. I might state that 80% of our expenses have been in psychology and not in hardware. The major point of research and development has been the study of the motivational factors involved and also the study of how does one go about tutoring. In other words, what we are talking about is using the computer as a substitute for a tutor, and I doubt that anybody in this room knows how to tutor effectively. That is an educational function that just never has been done, so one of the first things that you want to do is decide how you go about setting up an effective individualized tutoring facility. Secondly, you have to decide what are the real questions involved in motivating students. How do you motivate them and so on? Our work has been done with both high school students and pre-schoolers in general. We have taken a more economical approach to this than setting up computerized classrooms. We have simulated the computer, which is much cheaper than putting one in because you can change it very easily. What we have done is to write course material in specific words to be presented by a computer and have a person present the material the same way. He will hold up the picture that the computer would show, he will deliver the same verbal message the computer has been programmed to deliver. He will observe the student's reaction, will make the same logical decisions as the computer would. We have done a great deal of experimentation by using this simulator. We have also done a lot of work in judging motivation to go into this. Dr. Lloyd thinks that the advantage of the computer is the ability to individualize, to individually motivate the students. We keep students going along after the time that our computer has been completely pooped out and, we have had young children on for three or four hours at a stretch. Lloyd wants to try some experiments where he keeps them on for eight hours at a stretch, with obviously something to eat in between. This doesn't seem difficult at all.

GERARD: That is a valuable contribution.

ATKINSON: The simulation is, I think, very important. It turns out that in development of all of our curricular materials we always get two to three hand simulations before it gets to the point of simulating certain components of the curriculum on the current system. Obviously the hand simulation just on a few children is going to get you through a lot of the problems that you would encounter immediately on the computer development. I hope you didn't misunderstand my earlier remark. I will be very interested in seeing this research when it is in the literature.

GERARD: This flip-flop on the computer simulation of man or man simulation of computer reminds me of that old one of the piccolo player who was called a so and so and it came back and was called that so and so piccolo player.

DAVIES: I want to discuss short-term and long-term optimization criteria now, and this is understandable because it is time that you would most likely to make a dent in. However, I am not sure that the suggestion is that we will wait until we develop the technique and then we will see the long-term optimization. The implication is that we are doing pretty well now, and when we start working on long-term optimization we will do even better. This overlooks the possibility that there may be some harmful aspects of the kind of program that we have been talking about, and that we are postponing any attempt to get a real evaluation of this possibility to the future. There is a possible damaging aspect. Of course, you are only doing this one hour a day, but still maybe by the totally designed curriculum you create the impression in the student that the adults and this machine in particular know everything he knows, that the system has great understanding of the world because he is restricted to taking certain kinds of branches and they have an answer for wherever he goes, and it is just great, and the world is a very secure place, and these adults really understand everything. Later on he is going to go out in the world and find these people don't understand anything, they can't solve the smog problem, the water problem, this problem or that problem; and I wonder if he is really being very adequately prepared in that sense. Because of this kind of danger I would think that even though we might not have good scientific technique for this long-term optimization now, it is very important that we try to make some value judgments, even if we do it on a very intuitive basis.

RIESER: I have one question I wanted to ask Dr. Atkinson about the nature of reflective time compared to active input-output time, if you will, in a half-hour period. I think of it because of a system we used with our undergraduates who under certain circumstances are obviously typing out at a rate that is much too high compared to what goes on in between and the teletype on occasion will type faster. Typing is no substitute for thinking, and I wonder how much reflective time you have programmed in for the students in the half hour period.

ATKINSON: I can make computations on that. I have never bothered, and in a sense it depends somewhat on the student. He can respond once the interim process command is initiated, and he can take considerable time before he starts to respond. I think my comment is that these are all tremendously interesting questions but I think Paul's comments are interesting too. You know, you have to have an ongoing system and you have to start getting experience in the system before you get answers to these questions. I think it may be a mistake to think that one can really conjecture answers to questions about whether you can take an hour of input a day or eight hours of input a day, or what shortcomings there are until one actually gets some real-time experience. I think the one thing that really impresses me about computer-assisted instruction is that very few people have any real science experience. I mean, everyone has a one hour program tucked away that he ran ten subjects on and he will give you no end of opinions, but very few people have a backlog of experience on what this is all about. I am not claiming to be one of these people. We hope to be in that ballpark a year from now. BARKER: I think I intuitively disagree with Kopstein. On the other hand, I gather that I am going to require reflection. JUSTICE: Since this is a conference on computers and universities, I might make a comment on the use of computers which is a little bit different from what we have been talking about this morning. It is also a little different from the way they are used in a mathematics class or an engineering class. That is,the use of computers as a substitute for a laboratory which is not practical on a quarter system. To draw from my own field,many biological experiments are too complex or too time consuming or too risky to do in a normal undergraduate laboratory. I believe that some of these experiments can be very profitably simulated on a computer in, say, a Monte Carlo manner, and I am looking forward to trying some at UCLA in January. From my own experience with modeling on a computer, I find that I learn a great deal about biological prototypes in the course of modeling. I think that the instructor could provide the skeleton or the basic general model for a given biological process, and in the course of a laboratory period the students would set up the experiment under the guidance of the instructor. They could design the experiment to be run on the model, the model could be run either on-line or off-line later on, and in the next laboratory period the students could engage in analyzing and wrapping up the results.

GERARD: This is again bringing the student into a creative part of the development. CORRIGAN: I have been listening to the points about some of the factors relating to technical things relating to the terminals-either, or, this form versus that form. My concern comes back not to which terminal but really what the orientation for it is. We are talking about computer-instruction for a learner-oriented approach which is really a response-oriented concept. Is this business of terminals consistent with the business that we are not ready perhaps to establish standards but are still in the exploration stage? That really we have perhaps a family of possible terminals and assumptions. There are many considerations with which we are concerned. Some are logistical factors such as reliability, and so forth. Some are the response requirements. What is it we must try to elicit from learners in terms of the functions we want them to perform? Having established these functions, what are the most appropriate design factors classification? How much time should a student spend on a pattern? What is the role of the teacher? I think the curriculum planning and instruction system design approach must be considered first. We have to start from the design considerations of the optimal application of the computer, and we have to design the various conditions under which we are going to use it. Until we formulate what it is we are trying to produce in the way of predictable performance, or the method of process we are going to employ, until we talk about curriculum and design and so forth, I have reservations about how these other things will fit together. So I would reserve consideration of terminals until we define functions.

WILLIAMS: I was particularly impressed by the emphasis on the extent to which this whole consideration of computer-assisted instruction does offer opportunities for greater individualization, for greater emphasis on the role of the individual in this process. Teaching may not always be individualized but learning is. And, as has been said earlier, we have done a lot of muddling through, not just in the elementary and secondary schools but certainly in the graduate divisions and perhaps beyond. Our colleges and universities assume that effective teaching-learning situations have been in effect when actually I expect they have not been. Anything that we can do, which assists in not only placing the responsibility more on the individual for his learning, but in making that learning more effective on an individual basis, is going to be a tremendous contribution. Motivation, also is much more likely to be accelerated when the individual does identify himself as an individual in this process in a more active way instead of in a more passive way.

Just as we have seen earlier abuses and almost throwing it out of the window because of the abuses, in so-called instructional television, I have been very interested in the suggestions today that surely let's do a good job of our research. Then we may know what we want to do and what the potentials growing out of the research and the experimentation are. I am not too concerned that we will find a way within the economic resources available to translate this into learning situations at our universities. GIVEN: It would seem to me that CAI approach is a systems approach involving technology, curriculum, teachers, and students, and that certain priorities must be set up. Among the subsystems, certainly the matter of the curriculum, what is going to be taught, is most important if we are going to try to decide what sort of technology we wish to use to accomplish this. On the other hand, I think that what Kopstein said earlier is rather important in that these things all go forward somewhat in phase. It is not a matter of one aspect of this making a great stride and other areas not. I think the big problem is a matter of how these things are phased together and the entire system moves forward. The only way to do this in the long run is through actually getting unlimited experience in terms of students. KEARNS: It seems to me that we are concerned with the conversion of the art of teaching, and we assume that people have been taught by some teacher and have learned. I don't hear too much in the discussion about what is being done to determine what is good instruction. I am somewhat concerned about what might become of teachers - good teachers who might develop systems to things being done in program development, which are extremely foreign. You might not be taking what we have developed in instruction and in learning by involving the good teachers. FLOOD: I guess my views are too radical. I am rather impressed with what seems to be, probably incorrectly, a very industrious approach. Let me make a brief statement. I don't think any of these things we're talking about will come up five or ten years from now for the following kinds of reasons. I am talking about the things that seem important to me for universities and colleges; I am making no comments about the secondary school. One reason we make the statement is that we continue to think of the college as being a terminal stage in the present sense for many people, and then there will be continuing education. I don't mean they will stop learning. I think we have an opportunity to have colleges run very differently. I think it is a great defect in our present colleges that students mostly don't learn by pairs and triples, because they like each other. They can't really talk in a classroom and it interferes with the recitation. I think that if we make information really available, for instance, through library information systems and what not, the students sit there and drink beer and talk to each other, exchange ideas, and learn. I think colleges will be extinct in that sense. That is enough of my radical view. GERARD: Nice to find that some of us oldtimers are still the most radical. I keep talking about the evaporation of a school (meta) physical emphasis. BLAKSELY: Dr. Miller's problem about backing up the manpower needed is why it is important that CAI become involved in the entire education process with the impact of graduate teaching. Conversely, I can see the problem of dollars. With the capital requirements such that they are hard to get from my constituents this means even more promotion on the part of the individual faculty. STARKWEATHER: I would like to make a comment related to what Davies said a few minutes ago about the notion that the student might get the idea that the answers are all known because the branches are handled or something of that sort. I think I have had some experience that would lead me to feel that it is important to some degree to engage the student in the process of constructing the writing program. If he does any of this at all, even a small part of it, his exposure to the devices would quickly get him over that idea, because in this situation he would be put in the position of first of all having to design and build the questions that can in some way be answered. Not all questions that students ask, of course, can be answered, and not all teachers recognize the difference and they handle them in one way or another,off the cuff at the moment. On the other hand, in building questions for systems like those we are talking about, one has to recognize that kind of difference and build questions for which answers can be arranged. The student in this situation then has to supply answers which would be considered appropriate one way or another, and he has to predict the kinds of responses to the question that might be made by his peers. In this case, he may very often be in a much better position than we are or that a textbook writer is in predicting the kinds of responses. The ways he would handle those responses might be ways the textbook writer would very seldom think of, and ways which might be especially effective and especially motivating. I think that the motivating effect of some of this activity is great on both sides: for the student who sees what the system is really like, from which he, on the other side of the fence, is going to learn things. And it is also motivating for another student who might just be testing a program for him to have some of the language vocabulary, terminology responses, and so forth to be in the language of a fellow student. EVANS: I have a number of questions that come to mind. I have heard descriptions of computer-aided instruction, and they sound closely related to the present state of developments with programmed instruction, which everyone says we are not very interested in here. I hear comments about reflections but I don't hear any instructive comment that lets me understand what is meant by reflection in terms of instrumentation, other than you allow the person to ignore the system for awhile. Of course, that is a motor reflection. I am surprised that we haven't heard such terms as "computer-aided teachers", which seem to me to be very appropriate, particularly for "computer-aided students". We have almost excluded configurated teachers. The idea of teacher-proof and computer-aided teachers are rather exclusive ideas, it seems to me. Certainly,at the university level I think we ought to be talking about the computer-aided teachers and the computer-aided students rather than programs in which the machinery takes over the teaching function. Those of you who have had experience with program instruction and closely related computer-aided systems: How much difference is there when the course of instruction is really essentially the same? Are we providing a short-term motivation in terms of being a part of the experiment and having dollars tied up in it? I would like to reinforce Licklider's point of view that we really ought to know what it is we would like to have. We can solve reliability problems in the long-term if we are working on the right one. We would like to know whether the graphical display and line drawings which we now have are at all adequate or if we should have half tones.

We would like to know what kind of manipulation of pictures is desired. So far we have only really talked about showing pictures but not about pictures, that in effect, have been created in advance. If one has a projected view of an object that has been created in advance, one needs dynamic creation of these things, manipulations of the pictures, and so forth. I think there is an idea of what is easy to use, people order a light pen or so forth. Probably it has been very much overplayed in the long run. We don't cast out pianos because they are hard to play. We find it worth learning to play the piano for the result and I expect we are going to use and have students and teachers interact with machines, over the whole career, the whole educational period. It is practical to have rather complicated interactions develop which are, perhaps, much more efficient than the things you know about and use the first time you step up, such as the light pen or something. I have more random remarks but that is all for now. MURNIN: As you know, I am here as an observer for the Office of Education. However, I have been associated with Title VII, the National Education Act,which concerns itself primarily with research and experimentation on new media, and I have been sitting sort of on top of an innovation in this country on terms of technical changes and so forth. It seems to me that the one person we cannot ignore is the teacher. I still think there have to be the interaction between the human being, the machines, and student. Interestingly enough, Dr. Evans, I did see a proposal from a a school in New York state. They have changed the syllabus for one of their courses in biology, and the proposal submitted was to develop a computer program in order to train teachers in the use of the new syllabus. At the same time,they are going to develop a parallel programmed instruction on the syllabus and one of the questions which we raised with them was this problem of inquiry. Biology, as you know, concerns itself with laboratory tests and so forth, and we were wondering whether a static program would serve the two purposes for which the syllabus was proposed. We suggested to them that perhaps they should involve laboratory tests in some way with the radical changes in technology. I feel another thing we should concern ourselves with is what are we doing about training the future teachers in the schools of education? I know that we have to live with what we have now, Dr. Miller, and of course this raises the problem of diffusion of information, the dissimination of research information, with the messages tailored to the appropriate target audience. I feel that we should be doing something with future teachers in terms of innovation. I have been through some innovation myself at Pennsylvania State University in 1956. We were one of the first to pioneer closed-circuit television. This was, of course, at the university level, and there were many, many problems of resistance on the part of the faculty. CARL RADICK: I am a bit bothered by what I regard as an "old wine in new bottles" approach. It seems to me that several fundamental questions, which have been dodged, are ones that really have to be answered before anything else is done. These are questions like, What are we trying to optimize? Is it appropriate to talk about optimizing? It is clear that if we are concerned with it at all, then we can say we are optimizing in the sense of minimizing costs per students. It is not at all clear to me that we can, in any meaningful sense, define what optimization is, other than perhaps maximal correct answers on multiple choice things. As an economist, I am bothered by Dr. Atkinson's example of economists not looking at the world when they are concerned with their models of optimization. Clearly if it is appropriate, for economists to do this, but it is not quite clear to me that this is what educators want to do, that they want to optimize. ATKINSON: You may be using the term in a different sense. RADICK: I don't think so. ATKINSON: I must add one remark to your comment and also to Dr. Davies comment. It is all well and good to say that everything should be set forth, and that we should understand what our goals are and what we are trying to optimize and what the features of the system should be before we build it. But I think if we wait until that point we really won't do anything. I just think that somewhere along the line we have to be willing to step out with a minimal system and a minimal set of goals and get some experience. I am plugging very hard for this idea that we should not always be concerned about criticism in the sense that you haven't covered all the cases before you step out to do something. I am not sure how to define optimization in some sense that is going to be universally satisfactory, and I can't tell you what the computer system capabilities should be, but if you are going to wait until someone else provides that information I am afraid we will never get the first system up. GERARD: Thank you all for a very exciting morning.

Tuesday, November 9, 1965

SESSION II

2:00 p.m.

CAI - TECHNICAL ASPECTS

Speaker: Ralph E. Grubb

Chairman: Fred M. Tonge

Because of a conflict, we shall switch tomorrow's afternoon and morning sessions. GERARD: Now I will call on Karl Zinn to report on this morning's summary. ZINN: Obviously, what I am doing is interpretation, not recording. I am proposing we look at this as an interface of the equipment and system with the learner and eventually this afternoon we have to consider other users besides the learner, the teacher, the counselor, the administrator, and the author of materials and so on. But, in any case, mostly from the learner's point of view and the way the system looks to him. And, then in subsets, from the administrator's point of view, in terms of cost, which must include communication cost and characteristics, reliability (in terms of the reliability to the user, not reliability of the component because it might change even automatically if it goes down and then), perhaps greater emphasis on capability or function. I have made a list to indicate that we have been talking about audio display capabilities, visual display capabilities where we have been concerned with size and nature of characters of graphic color, dynamic display, otherwise motion, for instance, by visual tape, by fidelity, and then, possibly, some other display characteristics such as computational or modeling or simulation facilities. We touched on just lightly this morning an important aspect, that is, response mode, the input characteristics,by indication,by pointing,or by diagramatic work as well as by typewriter. Then, even more important, how is this to be processed, how is the machine to interpret or evaluate these inputs - the capability of responding for the processing. A fourth important point in terms of interface is the interrelation of goals, software and hardware. If one rapidly cycles among these in attention one is much better off than saying, well, first what we have got to do is decide on goals and then we decide on the software needed and then we go to the manufacturer with our requirements, but rather it is an interplay. Uses and validation is not a useful type. They seem to get lumped together here. We are pretty much agreed on research value if we only look around at projects that have been funded, plus curriculum development as well. We tended to point to things like individualization as a good thing, and I doubt if we need to go into this in more detail but there seems to be a lot of support for this as the appropriate criteria to use. Now, the active goal of the learner, and I mean to include not only your actively responding to a linear program such as the response program, but also certain components of this active role in which the student is somehow running a laboratory at least, a continuated mode, or perhaps monitoring an experiment and he, in fact, is controlling what is going on. Emphasis should be placed on validation being made external to this system as well as internal by asking questions about what we do in other learning environments as a computer-based one and outside the formal learning environment. Some people refer to this as ultimate objectives and long-term goals so there is a variety of terminology contrasted with internal or terminal goals. I am suggesting that we consider problems of the teacher role, of the integration of computer system materials into the larger educational system and of the acceptance of this technology, of this support system by potential users on the large scale. In terms of curriculum development, I would not necessarily agree that there is concurrence with methods. ZINN: The point is, we don't have agreement that the machine is useful for certain particular instructional strategies or materials. We certainly don't have evidence yet. I guess there is not sufficient recognition of the hand simulation technique, the human strategy evolving the material or testing things, dry running things in advance of computer implementation. I think this is partly because our user systems aren't very handy yet and were they more convenient we might find the computer playing a larger role, in any case, the current use to emphasize the human role, the need to work with humans in testing material. TONGE: Thank you, Karl. We'll now proceed with the afternoon session which is billed as CAI - Technical Aspects. I suppose one could contrast the morning and afternoon by saying the morning would be concerned with the weapons and this afternoon we are talking about delivery systems. I gather both from some of the talk and the list of questions that, in fact, we have been talking about delivery systems this morning also, and I don't think there is going to be a problem of when you look at hardware and software of going three hours in reciting questions. Before I introduce the speaker, I would like to exercise my prerogative to make one or two comments or ask one or two questions. One, I hope that we can avoid concentrating too heavily on hardware, we are talking about a system that includes software, that includes people in addition to the students, includes the teachers, includes consultants, and so forth. I think it is very easy to get involved with light pens and scopes and all this and the details of those and not worry about some of the problems of creating and using software. Another thing which occasionally is disturbing is the lack of citing specific evidence. I think there is some evidence on many of the questions that are ready. We have in the audience people who cite specific costs and alternative of this can make fairly reasonable estimates for two or three years in the future at least. It is important when the question comes up that we try to get what facts we have out on the table rather than arguing about what might be. I would again raise the question of what it is that we can take away from these large projects which so successfully have demonstrated a number of the things we can do using computer remotely, such as Project MAC. I would like to make one other point. We were stuck to this active role of the learner. We would expect students in a classroom to ask questions not just to respond to the teacher's questions and not just to work out equations, but go to the library and look up things. In general, in any of these computer systems there is something which you might call a data base, not structured as we think as structure in data bases always, but there is a whole data base concerning bigger course material, and it seems to me that we might consider striving for arranging in such a way that a student can inquire of that data base not just in terms of asking for a definition of a word or something but to ask, raise the relevant questions that come to him at the time.

Our speaker this afternoon is Mr. Ralph Grubb, an educational psychologist with IBM Data Processing Division, White Plains, New York, and also a research associate with Columbia University. Mr. Grubb was one of the three psychologists who founded the computer-assisted project at IBM Research Laboratories. He cooperated with the original Course-Writer system, and has authored a statistics course in CAI. He has given a large number of papers at national and international conventions on computer-assisted instruction. Next month he will be going to Israel on a United Nations mission to conduct a workshop on educational psychology. GRUBB: Thank you. I might say that after that introduction, children are very refreshingly honest about many things. It turned out that I was giving a telelecture to a new media workshop in Colorado and I was home, of course, sprawled out on my bed. I thought I would be very comfortable during this part of my presentation,so my 10 year old boy was listening on the phone while they were introducing me in Colorado. After introducing me in a similar way, he handed the phone to me and said,"well, so what else is new?" It turns out that whenever I speak on this topic I lapse into a convocation address. I think I told this to Lou the other day, but we share a personal story that I can tell on myself. I was talking at a small college and was giving a convocation address to their faculty, and it turned out that I had spoken much longer than what I had thought because I was going on and on about scholarly pursuits in education, of course, any convocation speaker has to galvanize the faculty into thinking about scholarly things for the year. I got my first cue that perhaps I was talking too long because the dean was sitting behind me and I heard this very slow relaxed breathing from him I thought it was perhaps time to finish, so I said "Let me issue a challenge before I conclude," and I said, "Let me say in the words of St. Paul, I beseech you therefore, brethren that you walk worthy of the vocation whereworth your call." I sat down. Well, apparently this awakened the dean out of his slumber because he jolted over to the lectern and in a kind of half-awake voice said, "Well, well, well thank you for those words, Paul." So I promise not to do that.

Let me give you a little bit of a roadmap as to where we might go this afternoon and recall the title, CAI - Technical Aspects. I hope that once again that under the chairman's direction, we won't necessarily get bogged down in hardware. That may seem strange coming from me, being identified with a company who makes hardware but the point is, I think that in computer-assisted instruction, there is primarily the software problem. The hardware, (and there is nothing magic about the computer per se) is merely a vehicle to carry out those kinds of learning strategies which one wishes to stretch himself to. In fact, I might even quarrel with CAI. I think in a sense, what we should really adopt is something that may sound like informational systems in education because one is really talking about a total educational approach. The systems approach is a multi-learning media environment which the computer may be, but really in a sense is not, the hard core of the entire problem. Once again it is really a software problem if you will, so I think that the roadmap that we would really like to traverse this afternoon might include the following things. After this morning's session I would really like to once again articulate what I think would really be a basic philosophy of CAI. I think, then, I would like to talk a little bit about some of the objectives of the program that we have been undertaking for some time. In fact, I might parenthetically add here that it would be tempting to reflect on those in great detail, and also to try and cover the waterfront with what CAI is really doing in the country. What I would really like to do is add just enough of our own experience which bear on many of the questions that were raised over here and then call on some of the others of you that I know have some very pertinent answers to some of the questions that we have been raising. After talking a little bit about some of the objectives of our program which include such things as what kind of technology is needed to carry out the kinds of objectives, and then, discuss what kind of software one needs. These would be, for example, a very simple author-entry language which would permit subject-matter experts who are perhaps naive about complicated computer programming techniques and would permit them to think of the terminal and of their course program, input their course program remotely from these processed teaching stations if you will. Then, finally, I would like to talk about some of the teaching-learning techniques that have been going on both in our house and some other places and a little bit about curriculum development and things to come.

Well, back to the first point then, basic philosophy of what comprises CAI. I would start out by saying that CAI is not automated programmed instruction. I think if that were the case we are wasting our time in the sense of utilizing some very expensive equipment to type out frames of material which some author has lifted out of a text and erased a few words. I think that the rationale for having a computer with all of its muscle and stored program logic is to do some of the following things: Simulation, for example, where one might have a whole set of contingencies involved in a pre-structured decision. Perhaps it might be trunkated so that the author doesn't have to go through every possible branch such as prestructure. It seems to me that the IE is the simulated laboratory,for example, it is extremely important in what computers would do in this respect. The whole idea of gaming and/or simulation, however you wish to break those, the idea of massaging the student's answer in some way. Perhaps we should call that editing, where the students give some complex response to a complex question and then the computer or the tutorial device or whatever edits that in some way and gives the student some selective feedback as to where errors have occurred in the message because it is not altogether clear that students can even discriminate the difference between erroneous response and the correctly printed answer that may be side-by-side, which was his response. The idea of, for example, looking at complicated teaching strategy. People have looked at guided discovery as one mode of teaching for many years. One of the ways in which you can cue the students into solutions of problems themselves, not merely telling them to,cueing the idea of using a response model, and looking at the effects of cueing the student in some way before he has responded whereas in traditional programmed instruction we have almost exclusively dealt with the problem of treating the student after he has committed an erroneous response. It seems to me that is an extremely fertile field. I am saying that CAI is not just a responding environment, but the fact that it is a dynamic responding environment which means that you are adjusting the course material or the test or whatever it is that functions student response history. You really, then, are talking about individualizing instruction. It seems to me that when Skinner and others years ago talked about programmed instruction and breaking the locksteps of education that what we were doing is merely taking students out of lock-step classes and lock-stepping them through linear programs. The idea of individualizing instruction, I think, becomes a prime requisite which may or may not look like traditional programmed instruction as we think of it. Well, what kinds of things would one need to address yourself to these objectives, both in terms of terminal, the CPU, the kinds of speed of banks, if you would, for storing curriculum materials and/or tests, student records, operating monitors, etc? I think these become prime questions as soon as one raises the objectives of the instructional process. It seems here to begin to configurate certain systems. Here I would like to show a few of the slides of some of the things we have been working with for a number of years at the Thomas J. Watson Research Center which is also part of an announced Course-Writer language. (SLIDES)

I mentioned simulation again, for example. Here a student is seated at a 1050 typewriter, the heart of the teaching station, connected to the computer. We have a masking noise. The theory is that this is a teletypewriter that is under computer control and what we did on this as a stopgap measure was to hang semi-randomly some audio-visual materials on the terminal, which is on the rear. They're under the operating monitor's control in the central processor which happens to be a 1400 series computer, a 1440. Here the Course-Writer language with which the author has used as a vehicle if you have material into the machine. He has indicated to the computer what slides should be shown and asks also what tape message, which here is out of sight, might be addressed in Course-Writer language. These audio-visual ... are all controlled by the CPU. In this instance, it happens to be a bridge hand in which the author was interested really in what would happen in a game approach where you had a finite set of alternatives in which the student would bid a hand of bridge with the teacher and then the computer would play with you the hand just bid. (SLIDE)

I merely show you this because here is the CPU of the other aspect of the system, which happens to be a 1440 and, of course, the transmission controlling would direct all the traffic from the 1050 typewriter. Then back here are the rods on which the disc-units reside and there we have the student records. We operated a monitor. I think that this is extremely convenient (picture) of this configuration because of its portability. For this task which I would issue as a requisite in the sense of handling course material.

The next slide shows you one of those disc-packs. Here the proctor is replacing the disc-pack and has as many as seven courses on there, with another one. The idea here is that the author may have many courses on the shelf and have fewer numbers than he has courses so that the portability of the disc-pack becomes extremely convenient as well as economical because of cutting down on the number of storages.

Here in the next slide is part of an open classroom that we had at the research center and I show you this for two reasons. Number one, the instructor is almost always in the room in which he is circulating around offering special help to the students and touches on this question once again of the teacher's role, which I would like to elaborate on later. From practical experience, having authored a course, and secondly, it shows you something that I tried to comment on this morning about optimizing course material. You can see here two students working cooperatively at one of the teaching stations. It was my experience in running 30 students through the statistics course which is roughly equivalent to a typical three-hour college introductory course in psych statistics. These students take on the average of 13 hours to go through the course and it is interesting to note here that in this,(maybe an OK word would be a Gemeni condition) the pairs of students working cooperatively were paired on a predictor variable which happened to be their College Exam Board score. I didn't think it was the best predictor variable I could find, but it was the only score that I could get on these people. Effectively, these 30 people were paired on either high scoring CEB verbal scores or low scoring CEB verbal scores, and then I had controls of highs and lows so that it was actually a little block design. Essentially the results indicate two things. Number one, pairs of students could go through the statistics course as fast as their controls, and, secondly, the pairs did as well on an individually written final examination as their controls. It turns out that the pairs wanted to take the final exam in pairs, too. But that would have been confounding the condition. Obviously, there is a missing element in the experimental design. You might immediately raise the question of what about a mixed condition such as a high-low pair of students working together? I just didn't have the time or students to complete that element of design so,essentially,I only had the four cells in the experimental design. In this instance, there is a looseleaf notebook that comes with the course and I think that will cue off another interesting question that might be raised as to the amount of hard copy that might accompany a course. Secondly, I think the whole issue of copyrights and other things will be up for serious discussion concerning the availability of course materials: author's rights, royalty-bearing arrangements, the whole host of other problems.

The next slide begins to show the author's role in the sense of the availability of terminal. Course-Writer is the language that grew out of my own frustration of working with this statistics course and having to interface everything through a computer programmer. Mrs. Selfridge, who worked with me is a very capable programmer, but she was also equally frustrated in having the two of us get together to do everything that has to be done so, between the two of us we set down a fairly hard core set of instructions that we thought would have wide applications to a number of teacher-learning conditions. What we came up with were essentially about 12 operation codes which would be a very simple interpretive language so that any subject-matter expert might learn the core of the language in something like less than one-half hour and then seated at one of these remote teleprocess typewriters could actually call in the Course-Writer language input his course program remotely from this unit. If one finds that a Course-Writer does not then begin to suit your needs as you get more sophisticated (even though it is indeed a very simple language, it is somewhat profound in the sense that it is open-ended) the one has the capability of adding subroutines in the language which, in this instance, is Utocoder so that you can call these in as functions or subroutines. They would operate on the student's response in a highly specialized way. It turns out that really these are quite necessary and quite powerful if they are used in the appropriate way. The operation codes are so simple that perhaps what you are doing is really tagging whatever you are writing with one of these outcodes like an RD for Read instruction or QU for question to the student or BR for branch or other label in the course, so that one can begin writing his course materials almost immediately. I think another first-rate powerful concomitant outcome of this kind of configuration is in a CAI medium. If you reflect back on the typical program structure heritage as we have experienced it, it has been extremely difficult, if not impossible, many times to revise the material. Either you learn more about them or the subject-matter changes or both, and so typically you had to call back all the field editions of the program and destroy them and update them. Here all one has to do is merely type in the changes and the whole course is immediately updated because there is only one course for that resident system. So it seems to me that it is an extremely important thing for authors, or teacher, whoever these people might be, and the ones who are making real-time changes in the course. It should be mentioned that authors are working more or less simultaneously with the students. It turns out that in this particular configuration there are 12 of these units working simultaneously.

I think the next few slides actually show you some sample protocols of the interaction between the students and some of the course segments of materials. It turns out that after the student signs on in a particular course, certain identification data come out like the date and time of day, 1300 hours for example, and the student's name is typed out in the student record file and what course he is in, a double check on the fact that you are who you say you are by typing in your ID number and also to confirm the fact that you are in the right course. It turned out that in early experiments we didn't do this and the student might sign on erroneously in the wrong course and work there for about five minutes, then all of a sudden realize that he was in the wrong course or in somebody else's student record. Well, of course, the operator or monitor picks this up where he left off in the previous assignment and so if he is in chapter 8 where the computer has issued a reading assignment, read sections 8.7 - 8.13. Then the typewriter types out after he has then read the assignment the standard, the difference is computed on mean differences rather than sample means. The student in this instance has to fill in some of the missing words, of course. Now this is one of the first courses developed along with Vernor Kopitz, who is in the room and the German course with which he is working at this time with Bill Uttal Many of our early courses did indeed resemble very much the kind of scrambled textbooks or had a close resemblance to the traditional programmed instruction. The next slide will begin to show some of the growing sophistication of response processing on the part of the computer, as indeed the conversational interaction as we refer to it looks more and more like the simulated interaction between student and teacher. Here we see the student's answer to the previous slide where he typed in the word, different score, and in Course-Writer we refer to that as the fact that it might be a predictable wrong answer. Predictable either because of one's teaching experience or prior student record; students have committed that kind of error and so he gets branched to an appropriate message such as how can standard error of the difference be a different score when it is really a major variability. Try again. So apparently that was sufficient to help him see the correct answer which in this instance was standard deviation, so he types his in and he is off on another question. It turns out that the rationale here is a kind of guided discovery mode so that hopefully you're teaching something like logical problem-solving, and at the same time you are teaching something about statistics. Of course, he gets chided for typing capital SD and the computer says lower case please and he does this and is now into a computational question. It turned out that in our early work on the 650 and on the 1410, we had a kind of super-desk calculator feature so that actually the student could ask at any time for computational facility and do all of his sums and squares and extract square roots right at the typewriter, which was treated as a simulated desk calculator. I should point out, too, that since this is a Selectric type unit we now broach another question about the type face, symbol set problem, or what have you, and it turns out that this was a real unexpected advantage of having a replaceable type ball because we had a number of type balls made up in special symbol sets like one for calculus, one in German, one in Russian, French and one in the Initial Teaching Alphabet, so that it is a relatively minor thing once one has the ball there, to merely change the ball and one is off in a new special symbol set for another course.

The next slide is part of a demonstration sequence which shows what one could do in a German dictation exercise. It is important, I think, to have ribbon color control for the part of the author because in this instance it is used very simply by typing out where the author has asked the system to shift to red for everything that is done by the student and then shift to black for the computer type so it is very easy to find the student's work imbedded in a larger list of computer typeouts.

The rationale here is that the computer is addressing a tape giving him some variable length taped message such as this CR by Knambeschaver and so the student's role is to type in the correct answer and a dictation mode. So he types in (a German phrase) on the first line and what had happened here apparently is that the author had asked for a subroutine to be pulled in if there is no exact match between the student's response and the target answer which is in memory in the computer. Two people at our Watson Research Center, Ed Adams and Bill Morrison, have been looking at this problem somewhat in detail which they call partial answer problem processing. The rationale here is, even though there is no unanimity on why one should use this, I think a very concrete example would be one in part of my earlier work in New York a number of years ago when we were using some programmed text, perhaps very naively, hoping that we were teaching remedial reading to young children that were retarded readers around the Morningside Heights area around Columbia. It was our observation that we couldn't even get that project off the ground, because in the best style of programmed instruction where you would have a frame of material, with some word missing and the students write in a constructed response, we would find that they couldn't even discriminate the difference between their erroneous response and the correctly printed answer, even though they might be side by side. These students would engage in mirror drawing,transpose letters, spelling errors, and so they would look at it and say it was correct and go on, and so what they were doing was really compounding their own erroneous work in a negative practice. So that the discipline of having the computer type back, such as in this instance as we see in black all the correct elements of the message perhaps, and insert dashes as to where he has erroneous characters, you are really giving the student some selective feedback to see where he has erroneous elements in the message and then perhaps you might permit him to try again. It turns out that the author also can manipulate a dynamic variable from question to question and that is essentially the percentage match that he will tolerate as an essential correct answer. If this is an early point in the course and he might be willing to tolerate possibly a 92% match and so, of course, the subroutine finds a greater than or equal 92%, I would say it is essentially correct and go on. You can actually manipulate the boundaries on the criteria on the range of students' responses and impose tighter restrictions as to courses and so on.

Well, you can see more of the same where the computer now has dictated another message that is in German, and he typed some approximation of this. In that instance the computer inserted dashes where his erroneous characters were and he tried again. In this instance, he typed it incorrectly in red.

The next slide shows the kind of capability you might have if you incorporate a dictionary look-up feature, which becomes something also of significance in a course, particularly in a foreign language where you may not necessarily be conversant with the vocabulary. In this instance, the computer has typed out a sentence in English and it is your job to translate that into German. And the sentence is, when you come to that, Ask for Mr. Taylor. The student didn't know several words, and he typed a slash and the words that he wanted the dictionary facility, for words that he did not know, and the computer then did a dictionary look-up and typed back the equivalents. Once again using ribbon color shifts, he typed in the German sentence and released that and apparently the author here has again asked for a subroutine such as editing or partial answer processing to come in and operate on this. It is no exact match and it tells the student where certain erroneous elements have occurred. It turns out that the author here makes a distinction between lowercase letters and uppercase letters which might be very important in a course like German because of the capitalization on nouns and so forth,and so an underline character is missing. The next slide is probably the last, and it shows what would happen if you would incorporate some fairly free running text and then, by using subroutines that would look for keywords which the author would specify and also a percentage match that he will tolerate in terms of criteria to see the response processing between the student and the computer. Here is a demonstration sequence which says essentially a legend connects Betsy Ross and George Washington. According to the story, what did Betsy Ross do? Knowing college students, of course, they will type almost anything so here is a very good example of what happened. This student typed "as far as I know she didn't do anything", so the author apparently called in some subroutines which would look for keywords, one of which might have looked for a negative operand, for example, and apparently got a hit there because it typed back almost immediately. Try again making your answer an affirmitive statement. Well, so this time he wrote, "she constructed a big flag", at which time the computer typed back "whose flag, which flag", so at this point he thought he might settle down apparently because he typed, "she sewed the first United States flag". Apparently, this is a common error and so a subroutine found United States in error and he gets chided by the computer by saying "the United States did not exist as such until after 1780, this legend refers to an earlier period", and at this point picked out certain keywords out of his sentences above with an apparent target message in memory and asked him to try, and he is now typing such things as"she made the first American flag".

There are a number of things that might be of interest in terms of some of the research capabilities, the technical aspects of the program. I think the first is the statistics course which I will describe because I know that best. I ran 125 through that course. You find dramatic time-saving with programmed instruction. I think one of the side effects of the pairs, for example, indicates that if you should tutor two students in a mode that might ordinarily take the time of one, it seems to me you are not only talking about social facilities in our social interaction at the terminal, but you can cut the cost of the terminal by a factor of 2. I think this has some important economic considerations at this early point in the program. It seems to me that as I circulated around the room I overheard a great deal in terms of the faulty interaction that took place between these two students. They would, in effect, at any one moment, both be tutored by the machine and then the next moment one may be tutored by the other by reminding him or her of principal factors in the last chapter or what have you, so there was a great deal of role interchange between the students. I think this is one of the things we lack in other modes of instruction at this point. I think, also, enough is not known concerning how one might carry out the style of process, for example, that Dick mentioned this morning. And so until more is known about that it seems to me that one has to build the opportunity for more and more dialogue between students, until such time we have the dialogue facility with the machine. We are still in a research phase where the machine is essentially controlling the students, not that I don't think any of us would like it to stay there very long, but still the technology is not yet advanced where we know very much about how we can teach two on a more equal footing in a man-machine interaction, at least in instructional process.

One of the other things that were noted this morning was the one that Dick raised concerning curriculum development and who might do this. My feelings have been very strong on this that obviously subject matter experts are primarily people who reside at the university because there you find most in terms of research familiarity, funding, a whole host of things. I think they are really people who should develop the courses, and until several years ago, the IBM Corporation sponsored what we call a Joint Application Study Development Program with a number of institutions, primarily universities, simply to try and meet this objection of asking who might really develop curriculum, and this really gets caught in a vicious circle in this medium, CAI, if you will, because even though we are in a research and development phase, one can't do research until you have curriculum as a vehicle on which to do research and end up on a spiral staircase. It seems to me that one of the things we have been looking at, the idea of offering this facility for continuing role and trying to investigate what the role of the teacher might be in curriculum development. I hope the afternoon session won't close without having Harold Mitzel chat a little bit about his program which was, I think, a question raised this morning about computer-assisted teaching. It seems to me that certainly one of the important aspects here would be a shortage of teachers. How could one utilize the medium and upgrade teachers, let's say, a new curricula such as was mentioned here in the modern biology series in the State Department of Education in New York or the Modern Math series which Harold Mitzel has been concerned with. I think these are imaginative projects and really are ways in which, by placing terminals in an institution like a secondary school, one has the concept of shared facility with another institution where perhaps teachers can't really get to a terminal, or perhaps get to an institution for ongoing inservice training projects. The only way is to carry education to them where they can get to a terminal for an hour or two a day and upgrade themselves in their own skills. Many others of you who are involved in some projects of your own in curriculum development. I think it would be presumptious for me to try to cover the waterfront, but throw out what we have done for an opening discussion and see what we can do from here. I think, Fred, I will close here for the moment and see what this opens up in terms of discussion. TONGE: Thank you, Ralph. You said you were going to say something about things to come and I hope we can come back to you later. ATKINSON: I would be very interested in the nature of your experience in curriculum, in terms of coding problems as you end up using a few macros. Are these macros from one course area to another and what is your conception of the programming task? TONGE: Could I follow up on that by asking that some time in the afternoon you perhaps enlarge a little on the 40 macros you referred to? LICKLIDER: I would like to hear further discussion of languages. I think there is a lot to be said about where language is going. GRUBB: If I may comment on that, the reason I didn't get into that is because Karl had put together a survey of some of those languages. We still might want to do that. FLOOD: This has also probably been discussed in Zinn's paper, but I would be very interested in a discussion of the experiments and graduations that have been made compared to successes, any kind of computer-aided instruction methods, the general effectiveness of computer-assisted instruction.

FORD: I would like to hear whatever evidence may be about the number of hours of human labor required for an hour of student time necessary and whether the instruction of languages such as Course-Writer really contributed much producing this time. BARKER: I know that there are questions of motivation here, but I wonder how one knows when it is worth going through the input procedure and whether it is worth limiting it to a student by reinstating the fact that Betsy Ross sewed the first American flag. ______: I would like to hear some comments with respect to the alternatives that we have for developing some kind of system for curriculum development, besides intuitively picking on people who we think ought to know most about it and are obligated to develop the curriculum. What other people should be involved in the pattern and what should the pattern be that is developed? In this particular case, I expect the system would be a set of people with some kind of set of rules, rigid or not, I am not sure, to arrive at what the curriculum is. LAMBE: I would hope we would structure the discussion in terms of valid course material as against curriculum developments. It seems to me that these two are quite different things. TONGE: I did not intend in my opening remark to suggest that we not talk about hardware at all, and that seems to be the way the questions are going. ZINN: Either in this discussion or in some substance, I think the relation should be given to the other side of the interface. If the functional characteristics are required or requested, on what interfaces acted in the machine, authors, and materials? ATKINSON: Hardware again, I think I have a set of slides that I can run through in less than 3 minutes,I will just give you a view of our lab. TONGE: All right, I will put that on the agenda. JOHNSON (a guest): I would like to have a few questions answered about the statistics course itself which was composed and administered to the 25 students. Was the course administered through the computer terminal or was it complimented by home study or classroom lecture? If it was done in 13 hours, how can you account for the fact that the college semester course equivalent was accomplished in 13 hours - would you say this is because classroom time, in general, is rather inefficient or is it just the new approach to the way you came about approaching introductory statistics? BARKER: It seemed to me that there was almost no discussion this morning of educational problems which exist with the kinds of education we have today, quite apart from the education as represented by this media here, as it should influence this community. Much was said this morning within the vein of how can we automate flash cards that the teacher used to use. Collect information about what the kids' responses were to the flash cards two weeks ago, and all that but still we mention the flash cards. I wonder whether any people in this community are really concerned about educational problems that are not a mere computerization of what the teachers in Alabama are doing today. This morning we spent a fair amount of time about the value of the teacher, and complimenting CAI, and whether the teacher should take an active role. Dr. Grubb thought that the teacher played a very important role, or at least he was present when the people were taking this course. I was wondering whether he had any practical knowledge gained from this and how fast the teacher's presence would help the students to master the course, in other words, he might come to a halt if we can't get over to the programmed text with the teacher present. The teacher could get them over it and may spur its completion by maybe a factor of two. LAMBE: In your opening remarks, you threw out something which is getting so large that it frightens me and perhaps we could have some discussion of this. Using the computer as the source of a rather large data base which students could in some way explore under his own direction, I would like to hear some discussion partly on how close such a consideration is to being in any way real. TONGE: I agree. Any Course-Writer course has in it implicitly a data base of that material - questions and answers and so on. Let me put in a question to broaden that. One of the things that have struck me is in looking at the current Course-Writer language, I would like to hear more about what you are doing at Stanford. Again talking about editing, there is a real gap between hardware and software as practiced by a few professional programmers and people working at machine translation and this kind of thing, and we see available CAI software which is an area for speculation. Another question: for years we were talking about whether we need soft copy for various applications independent of the computer instruction or helping programmers sitting up the terminals to help solve their problems. I would like to hear any evidence we have on the relative merits and necessities for such things as instructional purposes of hard copy and soft copy. BARRUTIA: I would like to hear more discussion about the application of the sound as it enters the computer rather than the typewriter as center of the computer. It was pointed out that the by-product is you learn how to type, how about learning how to listen? I am not referring to only more languages, but, basically, in English, and understanding kinds of things we have all been understanding this morning. This is a combination of the psychology of learning and also the hardware involved. I am thinking of perhaps a taperecorder or video tape recorder should be the center rather than a typewriter. TONGE: Certainly, in my hard copy vs. soft copy, I was limiting it much too narrowly. We had a couple of items on the agenda left over from this morning. One is slides, another would be reports of CRTs; I think Ralph said he has done some work on it. Karl Zinn also has some facts on available terminals and their costs. Suppose we take those two as a matter of presenting some evidence on which we can continue the discussion later. GRUBB: I think the observation was made this morning as to the relevant merits of a typewriter compared with CRT and how expensive are they. Is the cost justified and so forth? If one starts out rather simply by using CRT as a character, generally, you are not going one step at a time. I am not going to say that let's start out by using this CRT, that it is a more advanced type where we are going to show slopes of lines of where the student has asked for the regression line of various distribution data. We are going to have this drawn out immediately for the student on CRT, but if we start by assuming that CRT would be a fast, efficient, quiet generator already the line of equipment with which I am familiar, namely the 360 line, the cost of CRTs, when you get multiples of those is already cheaper than the 1050 teleprocess typewriter. For example, the cost of the CRT today if you get 24 of them on a control unit so those things rent for roughly $89.00 per month without the light pen and other capabilities. You start adding on optional extras like vectors and you can run the price up. A stripped down basic CRT to hand on a CPU for 24 of those and that is 1/24 of the display control unit it costs something like $89 a month and that is cheaper than a 1050. ZINN: Where do communications costs come into this? GRUBB: I am not assuming communications cost because I am assuming it is a teleprocess unit, 2040 which is a slight control, but on the 1050 you don't talk about teleprocessing charges either. ZINN: You sure do. GRUBB: Well, no, I mean, I am talking about the hard price one pays for the rental of the equipment. ZINN: There is the hard price for IBM and the hard price for communications! All I am asking is, when one looks at terminals one has to be sure to look at both of those costs because not all terminals require the same kind of line and same kind of service, as I understand it then,you don't need a separate communications line to the remote computer for each of these 24 displays, just to the control. GRUBB: The 1052 was the printer and the 1051 is the logic box. Those two rent for roughly $125.00 a month. ZINN: Then the cost is about $1,000.00 if you buy it outright? GRUBB: It would be rather higher than that, $5,000.00. To that you would need to add then your several features which ought to be hooked to a pile of lines. Then after you add those in you have communication charges, which need not be 1 per terminal because you can have several of those using the same problem, not the same line. ZINN: You introduced a line at about the same cost depending on how much equipment you ask for on the 1050, but both are considerably more than a teletype.

I have something here that I can pass around or make available or useful. Terminal devices are information gathered for on-line University of Michigan 360/67. Now, it doesn't cover a wide variety of manufacturers, but it does give specific costs for teletype, also for communication requirements at various data rates. So it is here for reference. I have one other document or outline that can call attention to or three additional things which I don't think have come up yet, that is, the level of capabilities starting with the very simple stored multiple response kind of device then to a typewriter, then hanging additional equipment on the typewriter such as the additional equipment you saw on the slides, then to scope display and storage scope capable of processing over voice grade channels and doing a large amount of work remotely within those restrictions, and then one of the things that require higher data range cannot be economically done along these lines in the systems today. _____: Can you give this on a dollars per month basis? ZINN: That is what I was asking someone else to do over the noon hour and I didn't have time to reduce anything from that, but it starts on the order of $10 per month if you can get along with a pushbutton unit, essentially an adding machine keyboard. If you can do your work with an adjective keyboard, you can do it for about $10 per month, and it goes up to $45 - $125 a month. (teletype) and the 1050 and 2260 on the order of $90 up to $250 a month. Do you have a figure on the add line on the color equipment? ZINN: Talking about $5,000, they would be willing to deliver a unit for somewhere around 10. I don't know what they would sell it for. A storage scope, the one I indicated has much greater so that is something intermediate. When you go to a higher data rating all are rather expensive. TONGUE: Thank you, I think that this gives a little perspective on which we can talk further then. FLOOD: Can anybody give a reliable statement about what will happen in the next couple years, anything important happen? EVANS: I want to make a comment somewhat related to this. We have been talking about two different commodities. We have been talking about bandwidth and we have been talking about things like logical capabilities in the global display, and character generator and so forth. Bandwidth is something we have been working with for quite a while, and we can expect relatively low rate of changes in the cost and in the unit bandwidth over a unit distance. I think that this state of development of the integrated circuits we can expect a very large change in amount of logical capabilities that we can have associated with the terminals at a given cost, so that I think that those here are impatient to get this done this year have got this problem. It seems to me that we can really let our imaginations go if we think about what local logical capabilities we want if we are talking about 10 years from now. Now, we can't quite be in a position Dudley Buck used to describe in which he said computers as smart as alleycats would be given away as free samples, we still have to buy the input-output, but we are going in that direction very strongly. SELFRIDGE: They will be giving away CPU's! I agree with you. With the communication costs which you mentioned, I think I disagree in not exactly as you said it. They ought to be a lot slower. But the kinds of costs don't reflect the needs of what they will give you is either a permanent dedicated line or a locally dedicated line that is not what you need. You generally stand, say, 2 - 3 seconds away, but if you're going to have a stored board switching system to handle this, the bulk requirement to the line is lots less, possibly a magnitude less, and anybody who is using 1050 can do it with hard lines. EVANS: You can expect two, three, four orders of magnitude with the logical capabilities over a period. _________: I would hope we could begin to put some pressure on the FCC and the communication companies to get a realistic appraisal of what the services ought to be and what they ought to cost. There is no use making very much of a move right now, of course. LICKLIDER: I had almost the same comment to make. Maybe I could say that if you think back about something happening in the course of getting business reliably over wires you see that the dataphone came in with 1200 and is now 2400 in two or three years and it will probably double again in the next year or two. _________: I agree we should expect real changes in both of them, there is a relative change too. This is going to be alarming on top of that.

TONGE: First question in the first area? Author Languages...I think this is the notion that is really being raised by some of the questions including my being able to interrogate the data bases, what lengths do we want to go to provide this....generality is now available and the programmers set of tools to the author and a third question is that of support. You can read this any way, in terms of support of what facilities besides saying, OK here is a language so program something and good luck. Also questions of standardization so that we get some sort of wider materials prepared. The second area, if you will, is the question of evidence, evidence under the present state of author-language and what is the state of the art. Next, development costs, that is, how much author time does it take to produce a given unit of material, and questions about the effectiveness of present material. However, I am happy we may deal with present material, what have we learned about curriculum. I guess the appropriate way to say it is cost effectiveness ratio. Then there are a number of questions dealing with the role of CAI in some broad sense. Not CAI in terms of Course-Writer language but CAI in terms of computer instruction in the total educational experience at the university. What is appropriate to do? I think very often we find that people who are just talking about different things with respect to trying to get across different kinds of material is very different from actually...so many foreign languages or something like that. Finally some questions about the student system interface, questions of parables, of essential abilities involved there and also questions about the supporting system that surrounds the terminal because the instructor may be available. I propose that we start at the top and work down trying to do something reasonable in terms of time. I do want to take up Ralph Grubb's suggestion that Harold Mitzel might say something about their experiences in systems.

GRUBB: I have a couple of comments to get this started. I think it is very clear, of course, that the big bottle neck in this whole process is the author himself getting the curriculum material into the machine. For the teacher it is time-consuming task; for subject-matter expert or team of such people to divide up the responsibility and to segment the course and to do the planning necessary and carry it out to cross fertilize, which I don't want to do very heavily here. It took me roughly a man-year to write the psych. statistics course, so if one were to do a little bit of mental arithmetic that would be roughly on the order of somewhere around 50 hours of instruction time or author time to something like one hour of instruction time at the terminal. That gives you a very crude kind of index. I have seen others which range from 25 to 1 to several 100 to 1 so depending on subject-matter experts, authors, etc., you can see that it is not a trivial thing to write a course. It seems to me that the real future in author languages would be have a computer help the author in additional ways by let's say, collapsing the subject-matter into.... so that the author can perhaps be supplied with some sort of verbal matrix of the kinds of things that are happening in a given subject so that you can, even with present state-of-the-art of author languages which I have not bothered to summarize. It seems to me that would be a great aid right at this moment without going several more steps in the development of the languages by collapsing the text. I mean such things as people have been playing with such concepts as how to abstract, for many years now, whether one begins to simply have the computer supply you with keywords or auto-abstracts of the documents or other kinds of relevant statistical data. It seems to be a great help in having the author see, in a summary way, some materials that he has, summarizing to the machine itself.

TONGE: You had 50 hours per hour of terminal time? And then there was another 130.

GRUBB: An hour at the terminal is equivalent to what, about 18 hours of the conducted course? All right, let's not confuse the author time....I want the product of these two to know what it will cost to program out. The students themselves run through the course in 13 hours and roughly in the neighborhood of what I used to cover in class in 45 sessions which would be 50 minutes each so we are somewhere in the vicinity of 35 to 40 hours.

TONGE: So that is like 650 hours to program a semester course.

FLOOD: Do students do homework?

GRUBB: No, but they did meet in a seminar which bears on this other question of the role of the teacher in this situation. I had them meet with me on a kind of quasi-seminar basis at several segmented points through the course so they might physically work on the machine for a period of about six hours which might be 1 1/2 hours a day, 3 days a week. Then they come to a seminar, interact, reflect, if you would, talk, and go back on the machine. That was not counted in the instruction time. The seminar ended at a total of about four hours seminar time.

LAMBE: I can offer one more figure for what it is worth. This summer at Seattle 20 man-weeks of work did about 75% of the sequence preparation for a unit on optics which we think will average about two hours of terminal time for a student.

TONGE: That was 20 man weeks which is a large number of hours.

GRUBB: I think Mitzel has some statistics on that from Penn State.

SELFRIDGE: You seem to be thinking that is a large number. Many of you here have written textbooks. I don't think any of your texts could have been written in much less than 2000 hours per course. It just takes a lot of time. I am not sure you meant it. You said the bottleneck of getting the material into the machine. Working with the machine takes a quarter of that time at the most. When you decide what you want to teach then you are all done, essentially. Anybody can do it then. I don't think you have a good enough course if you can do 1 out of 25 hours of your time. I think you are probably falling down on the job. It ought to be 1 to 200 at least, just from other people's experiences in education. It takes a lot of time to get a good textbook.

LICKLIDER: I think it makes a fair amount of difference what kind of teaching or learning is going on or is being facilitated by the computer. If we perseverate for a minute on the subject of drill which we started out to deliver, it seems that once you do get into the programs and understand paired associates you could just fill the machine up from tables to dictionaries to language vocabulary and all that and forever after have the thing running so that the ratio would be something like infinity to one. Running time to preparation time and going in other directions at which we were trying to give very special attention to presentation of a subtle idea might go nearly as far in the other direction.

MITZEL: There is a variation in authors and in the way in which authors work which I find very difficult to estimate. We have had some authors that are very, very productive and move right through the material given certain kinds of backup and technical assistance and others tend to program the way they lecture and they have to keep going back over the material to make it so that it is presentable by the computer.

TONGE: Could you say a little more about the back up in the systems?

MITZEL: We operate on a team basis. We have a pattern man who is a faculty member responsible for the course. We try to have an educational psychologist on hand to help implement new and presumably better teaching strategy, and each author has a half-time graduate assistant. We also have an input technician. She does all the checking and that sort of thing. So for each man-year of author time, there is at least two additional man-years of somebody's time to back up.

TONGE: Did you have this sort of assistance from the number you quoted for Seattle this summer?

LAMBE: The figures I was quoting were for professional people at the time but didn't take into account the people who programmed and typed.

TONGE: And there were such people in addition?

LAMBE: Oh, yes.

TONGE: What about in your case, Ralph?

GRUBB: Equally true, I had the benefit of knowing the year before that I was going to write this course. It turned out that I was teaching the course in a conventional way, I was constantly at every point thinking about how I would do this if I were doing it on a machine. I even had students keep diary studies and hand them into me weekly as to what they thought the strong points and weak points of the course were. So these kinds of supplementary aids were of tremendous help to get the material into the machine. It is difficult to evaluate how many hours they took simply because to assume that this person would be an experienced subject-matter writer would be writing the course anyway so brings the experience ordinarily to the sessions when he segments the course.

STOLUROW: I have just made some rough calculations for an introductory course in logic. It runs about 15 hours a student per semester on my time. This is rough, about 2800 hours of developing time including rewrite, so this is not computer-assisted or programming or typists. This is professional time only in preparation of the material.

TONGE: But it did include some engineering of the product, that is, running some trials, going back and changing.

STOLUROW: Right, where the program writers were interacting with students.

ATKINSON: I was just thinking that the concept which people were describing and curriculum writing I think are really quite different than ours. I think our curriculum people almost write at the flow chart level. In reading, for example, we have a group of about seven people involved in the project, a linguist and other part-time linguists, and people who have had teaching experience in the early grades and some very bright graduate students. Every week there is a new meeting to discuss what topics are open, what areas are in the current process of programming, a discussion in some detail as to how to outline a certain set of materials. Usually two people will work on details of that and they will split the task up, and will write a flow chart. This will then be checked by someone else and usually about two stages later it gets to another crew of people, who then go through it in great detail and prepare it for the computer program. By the time it gets to the computer program there is still a lot that is left open: the exposure time here, what is the delay there, and so forth, but the computer programmer then works directly from this semi-detailed flow chart. She occasionally will have to go back to the initial curriculum writers to tack on an interpretation. ....Although they have to be familiar with the sorts of operations, but they are well removed from that aspect of it.

KEARNS: Since one of the reasons for the development of Course-Writer was to develop a simple language so every author could write his own material, it seems we have projects where people who know the subject matter are supported by people who really know computers and how to get it in. I was wondering, when we talk about the future of author languages, whether we should use more powerful language, forget about the abstract and making it simple, just have people behind them who know far more about computers and using these languages.

LAMBE: I would like to respond quite strongly to Jim Kearns. It seems to me the question of simple author language, in the sense of routines you call on for pieces of material in different ways, is completely irrelevant to the author. We found that the great advantage of Course-Writer as an instrument for putting sequences on the machine was simply that we could hire freshman students and they would do it for us. But I speak for myself, I mean, what the professional people are doing is, of course, trying to determine what the sequences are and that is all they need to know, not what options are there for processing?

TONGE: Maybe we really are talking about the way in which several projects have carried out their business.

MITZEL: Let me begin by saying I shall try to distinguish between future and current operations, and if I don't make this clear, I hope you will call me up short. We began with a joint study arrangement about eighteen months ago at Penn State and we have organized what we call the computer-assisted instruction laboratory. Our objectives in the first fifteen months were a feasibility study of teleprocessing for four college level courses. The second year of that same project we arranged to do, which we are in now, a field trial of those four courses and to insert audio-visual instruction into the Course-Writer. We have, since that time, begun another project which involves three courses at the technical education level, first two years of post high school, and I will give you details later on about those three courses. We intend to research on computer -assisted instruction on those three courses.

We currently have two IBM 1050's of the kind you saw on Grubb's slides with the audio-visual units, the tape, etc. Each terminal or each student station has a Monroe printing calculator and in addition, the static display as are needed by the student. Dr. Flood asked about to what extent our textbooks are used. Textbooks are very much in evidence in our courses in addition to charts, diagrams, things that the student writes on. In one course we even have a real life skull as a static display. It wasn't mine! Let me talk about our current status in terms of course-writing. By the end of June it is my opinion that we will have four fairly complete college level courses in Modern

Mathematics for Teachers, Cost Accounting, Engineering Economics, and Introduction to Audiology.

Like Atkinson we decided that in order to do any research in this area you have to get some experience. You have to know what are some of the parameters that you are dealing with, and we decided that the best way to get those parameters was to actually build some courses that would be presented by the computer. At this point we think we are ready to move off of that ad hoc posture and to study some of the internal problems that are connected with the CAI. One of the problems we are dealing with is this inductive versus deductive. We think we can take the same course materials and build inductive programs and deductive programs for it. One thing of great concern is to test Broadbent's single channel theory in information processing. Because you have a typewriter and a slide and a taperecorder you can present these to the students simultaneously or in any sequence you want. We are interested in random versus ordered sequencing of material on the assumption that the work being done in program instruction does offer guidelines for this question. Answers for CAI are going to be different than they were for linear programs presented by programmed text. We feel the need for hard copy, and it is something we want to pass out to you now. I'll come back to that and you will see how we use hard copy in what I think is a creative educational strategy. We deal with what Stolurow calls on-line contemplation and we try to use that. We don't mind if the student waits a little time in thinking about what we are trying to teach him. We actually program in a wait function in certain end pieces. We feel that there is, although the advantages are obvious for the CIT displays, one major drawback, and that is you can't get very far away from your central processor with a cathode ray tube. This is related to the whole problem of shall we have single purpose equipment systems or shall we have multiple purpose systems and try to program CAI onto them? It seems to us the multiple-use system or time-shared system offers the best short-term advantage for computers, which means that we hope to have a central computer at Penn State and be tied to terminals throughout the state doing various specific jobs with it. We will have, on July 1, two terminals at Williamsport Technical Institute and two terminals at the Altoona campus....These are about 60 and 40 miles respectively from Penn State. In addition, we will have four terminals on campus at that time.

Let me just mention in the future's department an application that we think is very important. We want to use the same CAI system to teach occupational information to tenth grade boys. Many of you know that the area of occupational information is one that is almost completely neglected by guidance counselors in high school. As a matter of fact, they despise it because they don't want to take the time to keep current on changes in occupations, and we have a project which starts January 1 where we will develop, using the CAI system, a key for teaching boys about occupations giving them a lot of opportunity to choose. If you have a minute look at this grey and red brochure. This illustrates one of our dissemination activities.

If I can get a plug in here for Joe Murnin's Division of the Bureau of Research, Office of Education, they have given us funds under part B, not only to test the capability of our courses, but to disseminate information about CAI. This was our first organized off-campus effort to do that. We took a scientific display to Chicago to a hotel and presented it at a meeting of the American Speech and Hearing Association. It was appropriate there because reports material on Audiology is about 95% of that clientele. On the back is the flow chart for the first part of the course, and the left-hand panel is the key to the flow chart. You will notice that the material is divided into four blocks: the outer ear, the middle ear, and the inner ear-- this is anatomy section-- and then a test block. If you look at item number 4, there is a choice. We give the student a choice to skip this block on the outer ear if he feels he already knows enough about it that he doesn't need it. In number 3 he has to know what is in it. And so on, branching back and forth through the program. Let me just mention the hard copy bit. If you will look at item 38 we ask a student if he wants to ask the instructor any questions. If he says he does we give him instructions about how to type his questions on the hard copy. This copy then is collected and given to the instructor, who reads these questions and organizes his lecture material.

This leads me to tell you how we intend to use the courses. The CAI material is designed to be approximately two-thirds of the course in Audiology. During the field trials, which begin next term, a student will go to class on Monday, the CAI people go on Monday, then each is responsible for scheduling himself for two periods during the rest of the week on the system. Then the next Monday he is back in class with all the students. The field trial I mentioned will run with approximately 10 students in each of three posts. There will be this CAI group, there will be another group which will meet on Mondays and will schedule themselves for two periods but this group will study individually. They will take the course material and read it under general supervision in a special library study. A third group will attend lectures, as we have always done, three times a week. I call this a field trial and not an experiment because we don't have control of all the variables. But it will begin to tell us what ballpark we are operating in with respect to how much the student learns from CAI experience.

TONGE: Thank you.

CORRIGAN: Going through the back page I noticed items 11, 15, 19, 20, etc., questions regarding the performance of the students--Harris calls it Greater Man. Are these the criteria that you select or how do you use that data? Item 15, does the student make a greater than 50% error, middle ear. Middle ear block, well, is 50% acceptable?

MITZEL: Yes, for this purpose I decided that was acceptable. In other places he has 33% error so we demanded more, adjusted to the level of difficulty. That is complete flexible, you know. You can go back and change it.

FORD: Two small points, one, I think there is no technical problem in remote cathode displays. We had one here ...

ZINN: Depends on what you want. Most cathode ray computers impulse from tube before you continue and if you are a long way away it takes a long time for the speed of light to cover that ground. In general the computer technology is not remote display directly coupled with the computer. That is color is not.

DAVIES: This point about which we were talking before about terminal devices. The cost of terminal devices is related to the cost of other things. This is known as computer use and down the line what you are using. If you are willing to pay for CIT display that has storage capabilities then you can reduce the line charges and use a remote computer. If you want to use a simpler CIT then the computer has to be nearby.

FORD: I just wondered if Mitzel perhaps oversimplified the important question of hard copy. Emphasizing its usefulness at certain points in your course it doesn't necessarily imply that it is a good thing to turn out reams of hard copy with all the interaction of student and machinery.

MITZEL: May I respond to that please. There is another use of hard copy that we are currently finding very useful. We are doing most of our course analysis by means of it. There is a function called student records but getting it operating is a tough proposition, and we are using the hand from the hard copy in order to study our own results.

TONGE: I wonder if I could change the subject and come back to further comments on this later on. The question of the role of CAI and educational experience seems to be one we ought to spend some time on.

ZINN: At some point we ought to read the names of other author languages into the record.

TONGE: That is what I wanted to do briefly and ask about the present state of other author languages. Has anyone any data on present material? We covered the other points but no one seems to be volunteering the hard facts about what has happened with material about which already has been prepared. Let's first take the question of other author languages. There certainly are some people here who have been working with other systems besides CAI, and I think Atkinson does tell us a little bit more about CAI and course writer II.

ATKINSON: I am a little reserved at this point. Apparently, there are a number of people here, including Ralph who know the Course Writer II. I am not sure what I can release at this point. I have signed all sorts of confidential documents.

GRUBB: There were some remarks at lunch that I have been speaking a little too freely.

TONGE: Thank you for being honest.

STOLUROW: Well, we have been working with our own primitive languages to try to develop not the kind of author capabilities that I think most of you have been talking about, namely one in which the subject matter expert tries to sit down and generate the individual frame himself in a form convenient for his expression later to be transformed by the language into the form used by the student. Rather, what we have been trying to do is to store modules in the computer which represent the syntax for particular kinds of exercises that are going to require repeated use for example, storing the forms of equations or various sentence forms where components of the sentence are represented as variables and other words are fixed and the variables have specified limits in terms of length but can be substituted with words or phrases to give them flexible meaning in terms of the student's ability to read this language. These are routines which are used to allow the subject-matter expert to specify various points in the course where he wants the student to get sufficient exercise in particular problems, specified a criterion so that the student has to solve a sufficient number of these correctly and then move on to some other subject, some other topic or concept. This permits the computer to generate materials required for each individual student where the materials are not identical from student to student, except in terms of their basic structural characteristics. The actual sentences that have to be diagrammed or the syllogisms that have to be judged in terms of their validity or the concept as the child is learning, or in English such as the notion of roundness or squareness and so on, can vary from student to student. The teacher is not interested in the dimension of the problem but rather in specified type of problem that he wants the student to master and specifies the criterion which would indicate mastery. Then the material is generated by the system. You don't have to write out all of the material, some of which may never be used at all. We have three routines that we generate of this kind and which we use in different parts of a language course, another in the larger in statistics.

ZINN: Some that you have read on pages 7, 8, and 9 of my paper. One is Leonard Uhr having done some interesting things using SNOBOL and only a simulated on-line system but providing certain capabilities that is somewhat of a challenge after Yorktown Heights and what was difficult and what was easy to do. The other is the PLATO group at Illinois having software which, I believe, is the best example I have of what effects have on levels of capabilities. At the simplest level the author simply puts his teaching frames and help frames, whatever it is, and the right answer into slots, in fact physically they often are transparencies, just pasted into place on a large sheet that is in the machine. This is the simplest sort of author language. At a more complex level would be something on the order of Course Writer where there is an implied logic to be followed and the author inserts answers and processing routines. At a third level in PLATO's software one can write his own routines in whatever logic he chooses, having the full power of the machine, the resident FORTRAN available on their system but also a simpler language on the machine. But it is all really the same language, and right or wrong, you want logic and so you start writing in FORTRAN or whatever you wish in an assembly line to achieve what purpose you want. A third one is Bolt, Beranek and Newman, which most of you are familiar with. A fourth one is SDC where they are working now on software, some of which is Course Writer but they intend testing slides built in for more flexibility. I might add a remark about Course Writer, gained from the experience of the authors at Michigan and talking with people at other remote installations. Perhaps you would like to respond to this. In general, the opinion is that it doesn't let one go beyond the scrambled textbook format. It does this in the way of special partial feedback functions that are very interesting in controls of logic and somewhat in concealment of other phases, but in fact, the bridge course is not assimilation such as the scrambled textbook, in someways more restricted than scrambled textbook on bridge. I know there is that much flexibility on hand in the statistics course. A number of courses I know of are for the most part, linear courses with remedial loops for correction of things built in but not the more complex variety to which you eluded for such computer instruction.

GRUBB: I think that by and large what you say is true. The early courses we developed were indeed not far removed from scrambled textbook. In fact, I think I made a point of saying that in the talk to the class. I think that the bridge hand you referred to is somewhat true, but the author did this consciously and in other words, given a prestructured contingency with playing all the hands the

the authors decided beforehand that this was not something that he was going to program for the novice, in fact it was really a bridge hand that he had taken from Goren's book of difficult hands, he locked himself into a very experienced player postulation, he just complicated the whole prestructure decision.

TONGE: I really feel we ought to spend some time on the role of CAI experience.

STOLUROW: I think the problem there is really a problem of criteria and that it is a trap that is very subtle. I think it should be approached cautiously because we are in the business of sampling both material, systems, and both sides of the balance, and generalizations are really unwarranted. About all one can say is that given Course Writer and CAI one acts better than the other but effectiveness is otherwise a pretty treacherous problem in terms of trying to get a generalized answer.

STARKWEATHER: I would like to mention another language which I worked on for a couple of years which Karl Zinn has in his listing but he didn't get to it a moment ago. The name I gave to it is COMPUTEST that implies the rationale of being interested in testing more than instruction when I started to develop it. When we end up with the functioning mechanisms, these, in many respects, overlap with the ones found in Course Writer. The materials we have worked with for the most part, have been in the area of testing, trying to push the limits as far as possible away from formats and forms open in free dialogue. Therefore, some of the mechanisms which were added along the way to Course Writer were a beginning point in testing Computest in their need right from the beginning to handle keyword ability and so forth and in this direction it still has some mechanisms that you have to have further macros or divisions to do the job of Course Writer. Therefore, from the author's standpoint, with his limitations; it is a good deal easier to work within this setting then others I have seen. Materials along the lines of individual intelligence tests type questions, of information variety, the responses to similarity question of what is common to these two things, comprehension questions and the interpretation of proverbs. Some of those get rather tricky to handle. We have gone as far as we could in the direction of data gathering from respondents and subjects with free interview operation so that we have had the program, tends to play the role on the one hand of the interviewer gathering data from the person sitting in front of the typewriter and on the other hand play the role of a ....you're.jostling..... typewriter.....interview.

As I understood Atkinson's last comment, he is not in complete freedom to discuss Course Writer or his experiences with it. This is a university. You were here on the university auspices; we are scientists. I would suggest that all references to Course-Writer be deleted from the record.

ATKINSON: I had some reservation on my remark. I assumed that Ralph would prefer to describe the new innovation.

STARKWEATHER: If we can't talk about something freely, without regard to IBM's notions on proprietory information, let's not mention it at all.

TONGE: I should point out that we shouldn't delete our references to Course Writer since we are talking about Course-Writer II or something independent of the issue although I agree that we probably shouldn't talk about Course-Writer II as long as we are not willing to describe what's involved.

ATKINSON: Anyone here can get the Course-Writer II manual if you want it. I assume that there are no constraints on the discussion of it.

TONGE: That's not quite true but I won't go into that. In any case I am going to insist that we change the subject at this point. It is indeed true that we can't say anything about the effectiveness of present material for reasons that sound like we aren't going to be able to say anything about the effectiveness of the next set of materials with the next languages or five years from now or so on and this is a kind of a bothersome situation.

RIESER: Would it be fair to pull a little bit away and try another approach that has been done with General Electric equipment actually at Dartmouth? I don't know any of the rules of what can be said so that I'll just go ahead and say it. The language that was developed by two colleagues of mine, Chris and Findley, called BASIC. You may know about it. BASIC means Beginner's All-purpose Symbolic Instruction Code. Our feelings were rather different from what I have heard discussed. Our aim is to have on the campus a computing establishment which serves all students and all faculty in a meaningful way.

It wasn't concerned with courses alone but trying to understand what kind of a facility you have to have so that every student and member of the faculty not only could use it but would know how to use it. We began with three hours of lectures to faculty members followed by use of the manual and an amazing fraction of the faculty showed up and followed it through. With students we took only two hours because students evidently catch on more rapidly! Indeed, our present system is to expect any student to take two terms of mathematics and that's certainly three out of four (90% take a term; three out of four take two terms) and in the course of this they all have two formal lectures with demonstrations on one of the_______ input-output stations. They get the manual and they receive a set of four problems which they are to do within the course of the term. In fact I should call this "instruction aided' computing" rather than "computer-aided instruction." The four problems are programmed so that if they have trouble, the computer helps them out. The important thing about this is not to program the math course or anything like that on the computer but to know that one can count, in three out of four cases, is the fact that every student who takes a course in economics or physics will have a dissertation and some of the faculty as well. The result has been that the programming, for example, a physics radioactive experiment is often done by the students even though they may be given a simpler program. Programming in an economics course will go beyond what the faculty can do. Third, if we try to make use of the computers part of liberal learning to a group of undergraduates, I'm certain, especially in professional schools, it will go to much more programmed instruction with the computer. We have found in this particular experiment that we have to raise the level of involvement of the whole institution with the computer before such a program could really be established in a way that's meaningful and in a way a student could really contribute. While I don't have the kind of proof of success that you request I can only tell you that we are now forced to go to a system of 200 terminals rather than 40 and to go as rapidly as we can because so many are using it in every aspect of their college work.

TONGE: Do you intend to keep the system just using what might be called a computational language?

RIESER: We use it in many languages but our purpose was as rapidly as possible to close the gap between the individual and the computer. Therefore, it becomes very apparent that to have a simplified language you re-route the computer into its true route on the campus within a period of 12 to 15 months.

TONGE: It seems to me there were some questions that led to this topic having to do with what sort of things we could use for the computer fitted into the total instructional framework and not just for the university but the relationship between the university and the environment, the Adult Education programs and so forth. I believe Barker raised a part of a question. Do you want to say a little more on it?

BARKER: I'm not sure that the kind of thinking I have been doing about it is particularly relevant to the university setting. Hopefully it could be. It seems to me that in this development of materials for courses ______________________ we need more interaction between the extra-school environment and what goes on in the educational problem. I recall when I was going to grade school they quit teaching cube roots and I raised a question about this because I was looking forward to this from the time I was in Kindergarten. I discovered that they decided that cube roots was a little passe; when Americans and Englishmen were going to sea in ships and to navigate apparently two groups were pretty important. This was back in the sixteenth, seventeenth, and eighteenth centuries. They continued to teach cube root into the nineteenth century, apparently, and right up to the time I started going to school. I'm sure that the earlier folks who started the cube-root bit were really grounded in the environment outside of school whether they recognized the real requirements for this particular piece of instruction. I'm not sure that the folks in the nineteenth or early twentieth century have stayed with that. We had this bit about Betsy Ross and I wasn't clear whether this was for college students or what. It seemed to me that there were many students around the Washington area, at least, who were learning a lot about Betsy Ross and not very much on how to live on $60 a week. It's that kind of objectives of education that I think I'd like to hear some comments on. Otherwise, it seems to me that we are going to get into the same trap of mechanizing the footcart following what's been taught in school, only doing it more effectively.

GERARD: I'd like to add a second to what you are saying. The mere teaching of simple rhetoric was not common at all more than two centuries ago or three at the most. Perhaps we are coming to a time when the resources available will make this an unimportant thing to teach any longer, just as it may become unimportant to teach spelling. Conversely, until there was printing available it was perfectly unimportant to be literate in a sense of being able to read and write. This was a very small fraction of the small population of the world that had any use for those skills. Therefore, they came into being as a result of technology and they may very well go out of being as a result of improved technology, and I think we should always be extremely sensitive to what the environmental opportunities, as well as problems, present.

LICKLIDER: I'd like to take up your question as a point of departure. It seems that there has had to be for efficient exploration of computers a separation between form and content. Betsy Ross was just content. The important part of that message was not Betsy Ross but was the idea of handling the data structure, which in this case is a simple string of characters, performing operations upon it and instrumenting an elaborate apparatus for processing, scoring and so forth which would make it possible then for the professor concerned with content to fill in whatever he likes. I think often the technician who is developing the methodology techniques chooses illustrative content without too much concern for its merit. It seems that we ought to dwell a little bit on the subject of data structures because they are so important. I think the weaknesses of some of the languages that have been described are due simply to the fact that they understand only a very few data structures. By data structure I mean that the simplest concept of Muninger, a little upstream the content of a table with columns and rows with perhaps column heading and marginal labels for the rows and the table numbering; these parts of the structure. Once you've talked about that table (perhaps you've written computer programs to handle display and so forth) then filling the contents of the table is a totally separate thing. I have the feeling that there must be dozens of very important data structures for educational purposes. Even if we take only generalized forms and don't bother about distinctions between tables with only two dimensions and tables with three or four or five. Part of the task in developing author languages seems to be to develop, to implement computer programs that will process; that will understand and recognize by name are more different kinds of data structures. Then we talk about what operations can be performed upon these data structures. There is another big field to master. I'll conclude that by trying to enumerate the operations, saying that in my view things like the sketch-pad programs at MIT, Lincoln Laboratory, ____________________________ graphical processing programs. Things like query languages and information retrieval are really more germane to computer-assisted instruction and the uses of computers in universities and education than are other things we have been talking about. I feel that computer-assisted instruction has developed too narrow a focus and we ought to widen it considerably. The simulation languages, particularly those that move on into dynamic display, introduce a new dimension; a completely new tool into the process of understanding. Some of Marvin Minsky's programs that display the dynamic way potential fields, fields of force and so on. A lot of persons get an intuitive understanding of what happens when you drop a billiard ball in a field of force that is covered by such and such an equation. This is a think that can't be done without computers. If we go back to the comment, "hand simulation is a good thing"; it is a good thing only if you're only going to get the computer to do what can be done by hand, but I defy you to make a hand simulation of Marvin Minsky's field of forces. Take teaching motor skills. The computer can get in there in micro-seconds or milliseconds since the positions to parts of the body if you instrument the golfclubs, it can tell exactly if the swing is coming across the ball for a slash or hook, you can then instrument the fingertips and convince the computer can teach you to type in avery short time instead of months or years. This is getting to be quite a speech but I have the feeling that thereis very much more to author languages than just does this string match this string and if so, to what degree, and what are you going to do about it if it matches more than 35%, are you going to skip or move on to step four?

MITZEL: I think there is a real danger of having an author language that will be so complex that we'll create with CAI some sort of monster that no one would appreciate. I would hate for our course in audiology to be the only audiology course to be given in the country, and I'd hate for Dick Atkinson's reading course to be the only one given in the country either. The language needs to facilitate multiple use where the curriculum decision is made at the lowest possible level, which I think is the local school.

LAMBE: Our computers are marvelous devices; they appear to speak and they appear to even think. Maybe there is a temptation to suppose that they are well-adapted in the educational process at the present time, simulating a human being. I think at this point one ought to say that is not a legitimate role for a computer; that it may in the course of time happen that the computer can simulate a human being and certain kinds of educational experience but not likely now. It seems to me the focus is appropriately on what kinds of things can one handle and then say of all those things that we do with our students. Is there a place for simple-response processing, handling, branching; can we find something to do with just a very, very limited instrument?

BARKER: I think that the distinction that Licklider made was a good one and I certainly wouldn't argue with the need for increasing sophistication in what I think you labeled structure. The thing I was taking exception to is once you've developed that then the professor is in a position to do whatever he likes. My decision is that we ought to find out more about what is required or needed rather than what the professor likes parallel to computer-assisted instruction.

KOPSTEIN: It strikes me that we seem to have arrived at the point that we shortchanged this morning and this is the fact that what we have now with hardware and software is a very potential, a very capable tool; a tool for doing something. But there is a question that is not peculiar to computer-assisted instruction. I think it is a question that education never faced. If you are to proceed with a computer base, the computer-aided instruction, you can't escape it now. We have to look at it. I saw this in the question that Bill Barker raised about how does what you are trying to do to the student, the ultimate product of this dedicated process. What do you want him to be? Why? This is a question that seemingly goes beyond this conference but I think it is so intimately related that it can't be ignored. I think that it relates to the point that Licklider made about the nature of the languages that are likely to prove most useful. What are you trying to do to that student? why are you trying to modify him behaviorally? This is the issue and I think the target toward which we have to progress in this whole development.

CORRIGAN: I think there are actually two questions I keep hearing. One is that the CAI is taking a look at computer per se, taking the fullest advantages of its unique capabilities. There are, by definition, certain limits and constraints of computer applications depending on what role you design for it and what role it is playing. The computer will process information in a variety of forms, shapes and manners. The point is I think, as Dr. Licklider pointed out, that problems relating to form or content are one thing but, it's also a problem of the relevancy of the material in terms of the relevancy of the objectives themselves; also in the design of the content; and also an underlying assumption for the use of computers--the predictability of achievement by learners. It's the response of the learners we are interested in. At Oakland Community College, although not computer-oriented at this moment, is a college designed for complete commitment to self-directed learning. We went for a complete summer with some 90 faculty members designing complete courses of instruction specific to designing or confirming what are relevant objectives; objectives in terms of what kind of learning outcome we are trying to achieve and trying to design a system which will achieve the index setting, the highest degree of predictable success for learners. The software which comes out of that is designed eventually to be compatible with computerized instruction, which is merely a tool for handling it under certain applications and conditions. So the concept of design, the first set of requirements which have to be considered in the sense of the rigor of design; of instruction materials which go into computers and increasing the efficiency of the learning processes itself. I think that's what we're here for, not for the transfer of information --but changing behavior of predictable matter at the greatest degree of efficiency. Design is paramount behind instructional systems and there are effective establishments which have been used quite successfully in in generating instructional systems which will work now and which will fit with computers later.

BARRUTIA: Examples are those language courses that we see all around, whether it's been done with Course-Writer or some other system. Language courses have always been traditionally oriented: reading and writing of the foreign language courses. We just don't teach foreign languages that way anymore. The National Defense Education Act with which we're involved has spent millions of dollars retraining our teachers to teach audiolingually. We start language teaching by the sound system; speaking and understanding first and then reading and writing. We arrive at the stage of reading and writing more rapidly by starting with the sound system; the result of all of the work that has been done in programming foreign languages showed that this hadn't been understood at all. Stanley_____had one program on sound and he's worked with John B. Carroll; there is another program by Matthew Sullivan of Encyclopedia Brittanica Films. All the other programming turned out of the CAI has been done right out of the textbook translating them into________by terminals. It's just not the way we approach languages anymore.

BRIGHT: I would like to hear about the plans of the people who have probably been thinking about this more than anyone else. How do you plan to use CAI?

FLOOD: I just have a brief comment to make because the things I am interested in saying can be better said yet tomorrow. When I made my remark this morning that I thought a decade from now the college and the university in the present form will be extinct I didn't mean that we would no longer teach students. But I had in mind the following idea. When we put a one-cylinder engine in a surrey with the fringe on top it was pretty exciting. The thing we've learned since then is that the motorized vehicle becomes important essentially after we have the roads. Then after we have the roads various things happen, and among them are that cities begin to appear in various places. So many things change. My first prediction in about five years as we do more of the very important sorts of things talked about at this conference is that we get all sorts of immediate and obviously critical problems moved along then we will begin to see the other effects. As we begin to become aware of the outside world, and realize that contrary to the intent of your question, I think we should build the colleges so they will produce the kind of people who get the right kind of environment outside instead of mechanizing the program so that will fit what we think the environment outside is. The reason I think that's the real difference is that things move fast enough now in terms of revision of the curricula of many other things, so that for the first time we can do that instead of matching our environment with our instructional program. That's how I use the transportation analogy. I have the feeling we should quickly recognize we control where the cities are going to be built or what the analogy is in our environment early in the game and build the educational systems and the library and so forth to go with it.

MILLER: I think we should get on the record a brief statement of what the Center for Research on Language and Language Behavior is doing at Michigan. Karl Zinn can give a concise statement about that.

ZINN: I would take this opportunity to present an example of another mode of input, namely auditory, into the computer. The rather sophisticated computer processing on this auditory input involves some averaging techniques so that the feedback to students is a display. that is a discrepancy of his pronunciation in regard to certain selective dimensions--the discrepancy of his pronunciation from the model which he is trying to imitate. In brief, that's the instructional role of computer in this system. In fact, this Center for Research on Language and Language Behavior is using this system to do research on ____________________ characteristics of speech and language learning.

GRUBB: It seems to me we've said something about other applications as well plus the role of looking at the problem of what should be programmed and what should not and what can be put down in other ways, what would be better left alone to more traditional methods or other kinds of innovations we can think of. We say that it was our original intent when we founded the present project, which was to take a fairly wide view in the sense that we would have a computer-controlled behavioral science laboratory. We were really thinking of CAI as we now talk about it here today as only one subset of many other larger areas. However, as we proceeded along it became increasingly apparent that many things could be done within the confines of the Course-Writer language as it developed for this subset of the total behavioral science laboratory. For example, about two years ago, as an application of what kinds of things we could be doing in this media, I took a standardized psychological test and then put it into the system in the Course-Writer language. The test was the Minnesota Multi-Phasic Personality Inventory. The many times that I have administered this test in the pencil and paper made to college students, they all seemed to score normal. In my opinion it lacks certain discrimination in the sense of separating students. I put it in the system in the Course-Writer language using counters and other kinds of things one has on automatic test-administration, scoring the ability to branch on the student's response history, etc. Perhaps one of the most important things was that by using the realtime clock in this system one has the capability of capturing latency or reaction time to each of the individual items in the scale. Perhaps that was the most important thing I did, because here is a test that ordinarily lacks discrimination, but when you begin to look at reaction items, which typically we behavioral scientists have thought to be the best measure of confidence a person has in his response, you begin to see very subtlely the way the students gravitate towards clinical scales that the test overtly just isn't picking up. When you begin to think of instruction in a much broader sense the whole field of psychological tests is one of the most fascinating areas of development, where one has dynamic test construction as a basis of the student's responsiveness. Let me just extend this one step further. In the pair study that I mentioned, one of the most interesting findings in that study was not necessarily the final performance measures as measured by final examination but an attitudinal questionnaire given to the students, which was an attempt to find out how they could conceive their own performance and that of their partner; if they had a partner; whether they were rejecting the pairing arrangement per se, or whether they were rejecting or accepting their partner as a person. It seems to me that what I'm saying is that the idea of monitoring attitudinal shifts, for example, during the course becomes extremely important. On the pair study it was interesting that 100% of the low pairs rejected the pairing arrangement. If they were going to be with somebody, they wanted to be with somebody smarter than they were because when asked if they had to work again under the same conditions would they choose the same person or a different person, about 70% of them said they would choose the same partner. So apparently they were not rejecting the person per se, but the pairing arrangement. I think Stolurow mentioned that people usually don't choose the thing that's best for them. It was interesting that the low-pairing arrangement reduced their error rate by a factor of two, I think over the low control. So they were rejecting the very pairing arrangement which was helping them go through the course in a more economical way. It's academic to take the next step of monitoring attitudinal shifts in a very sophisticated way even within something that seems as simple as the Course-Writer language.

I would feel less than frank if I didn't clear the air about statements that Dick Atkinson made about Course-Writer II. I think it would just be appropriate to make one statement so that we don't have to go around clearing records about Course-Writer II as a language. Dick said that he felt that one of the prime requisites was reliability in the system. I think when he asked us to configurate a system of certain requirements we agreed that reliability was very crucial so by mutual consent the system would go through a product test capability to help assure that the company's policy is that you don't talk about things publically until they have cleared a test phase, which a common procedure in tests. I think that helped clear the situation. It's a good policy that people don't talk about it until they have been officially documented and cleared a certain procedure that's known as a product test.

ATKINSON: It is awfully easy to say that we are not using all these things in the most sophisticated fashion possible, and I think that even at the simple level we are operating at that we have tremendous problems in terms of knowing how to treat the data and how to use that data in terms of future decisions. I can see a 15-year program that could evolve out of researching the aspects of initial reading instruction in this framework. I'm not about to accept the idea that when one ventures out with less than an ideal system one is wasting time for the long haul. Licklider, I hope I didn't misinterpret you, but I don't think you would necessarily disagree with my remarks but I think it's my response to the Easterner who thinks that everything should be done in a very sophisticated fashion, and if you can't point to something that's less than really the nicest way of doing it, you shouldn't be doing it at all.

LICKLIDER: When I had a fling at this field I did the simplest thing I could think of to do which was to automate a kind of drill that modified paired associates so I don't object to doing simple things; I think, as you say, this is a very long effort we are heading into. You might as well make progress where progress can be made. I would say when it comes to making languages to facilitate the work it would be good to make them as open-ended as possible so they don't constrain imagination and creative effort. That was my main thrust against constrained language.

DAVIES: I just wanted to make another comment on what Dick said. I think no one is really objecting to some of the more simple and straightforward experiments; it's the only place we can start. But what is important is to develop testing and evaluation means as you go along so that you are attempting to determine what are the values of some of these things in a long-term context so that you [illegible] get into a position to evaluate some of this work as rapidly as possible and know the respect from which the modifications can be made.

KOPSTEIN: In the comments of both Dick Atkinson and Licklider I see no real contradictions because we could work at different levels at the same time. I don't think that the type of work that Atkinson and Pat Suppes are doing at Stanford, while it is in one sense more simple-minded and less sophisticated than say the ________ work reported by Swets and Percy in the recent issue of SCIENCE, they complement each other rather than contradict. I don't know where the difficulty is unless one is sensitive about the level at which one works.

ATKINSON: I must say that our goals are really quite different than, for example Swet's goals; we are interested in an environment where we feel we have some hope of getting a fundamental account of how learning proceeds and there are constraints that we are happy to put on to our tasks, because we think within those constraints we can offer a description. In a certain sense there are often times when we are running our curriculum knowing full well that it's probably not doing as good a job as it might do if we were doing it somewhat differently. This can certainly be a shock to an educator when you impose this on any child, but it's a frank view of certain aspects of our curriculum.

TONGE: I'd like to make two comments: one, particularly on this last exchange I still have a very uncomfortable feeling when I see the tools which are handed out under the label programmed-instruction, etc. lagging considerably behind what I think is the state-of-the-art in handling textbook materials and in using the computer. Maybe I'm wrong on this, but having looked at a number of these I have a feeling that it is lagging. It's not lagging by six months but rather by two or three years. The other comment is I feel a real gap. We suddenly skipped very detailed discussions of what was going on, what tools were available and what had been accomplished, to agreeing in many different ways that there was a large problem within the context of educational environment.

Wednesday, November 10

SESSION III

2:00 p.m.

Library - Handling Books and Their Contents

Speaker: Robert M. Hayes

Chairman: John E. Smith

SMITH: Ralph Gerard has asked me to start this morning with a report from Jim Kearns on yesterday's session.

KEARNS: On author languages we found that there was a variety at present and also that there was an issue as far as the future as to whether we should stay simple or become sophisticated and I don't think there was any agreement on that. On the question of producing course material, there was a large variation in cost per hour. The variables seem to be the support of professionals, the subject matter, the knowledge of the field, and the accounting system one uses in arriving at the cost. The experience in using CAI (there are several on-going projects) all seem to be operating differently with different modes of operation. I think we could say that it's too early to say just what the effectiveness of CAI is. And then the role of CAI in education; it depends on your goals of instruction and it also raises the question: is the system design independent or available in foreseeable technology? SMITH: I am told that informality is the rule and I will not make a lengthy introduction of Bob Hayes, whom most of you know. I will update the title, though, by which some of you may know him. At the Regents' meeting just a couple of weeks ago, his title has become Director rather than Associate Director of the University of California's Institute of Library Research. Bob's subject this morning is a toughie, "The Library - Handling Books and their Contents." I'm sure, though, that it's not too tough for Bob Hayes.

HAYES: It is, particularly in a group like this, where anything that I say is obvious to everyone here since you're all involved in this kind of work anyway. But since my role is apparently that of setting a stage, I've made some notes with the intent of defining the problem and concern of mechanization, computers and other kinds, in the handling of books and their contents. I think we have to start out with a basic question, the answer to which we know, but the basis for that answer I don't think is at all obvious, and that is, do books have value in a university? It has been said for some time that the library is the heart of the university and this is repeated time and time again so I suspect the answer is obviously yes, but how large a library, how is its value a function of size, how does it relate to speed of response, to the selectivity in the choice of books, to the costs of getting them into the collection, of which acquisition costs are the least part, these are all very unanswered questions at this point. So we're starting out, when we're talking about handling books and their contents, in a poorly defined environment, namely the value of doing so. However, excepting this, there is a dream of the future, which all of you are familiar with and which I would like to recount, however, which represents the dream of using mechanization in the library. So let me cover this in about seven quick steps and then raise the questions which occur to me about these seven parts.

The first part of this dream is to store books in automated form. One kind of dream has been that this could be done at the time of initial creation; that is, as the author or his secretary types and the contents are approved, this becomes part of some basic store, available on demand. If we can't do that, then perhaps we can record in mechanized form at the time of publication and since the computer is becoming more and more involved in the process of publication itself, perhaps we can get the text at that time. The third approach is, that in the event that either of these two fail, perhaps to use character-sensing equipment where the existing text allows it for mechanically reading the textual information. And, finally, lacking any of these, we can use some kind of image recording, either micro-photographic or video, to at least get the image into mechanized form. Well, all of these have the purpose of meeting that portion of the dream; namely, to get the text or at least an image of the text in mechanized form.

The second part of the dream is to substitute the computer and some heuristic processing within the computer for the intellectual effort involved in indexing and cataloging. This involves, for example, text processing, combined with some kind of heuristics for recognition of the information-bearing elements. It also involves, perhaps, a mechanical process of glossary-maintenence so that the mechanical glossary can be used for translation from texts and eventually from requests as well to more or less standardized language. Implicit in this is the use of some kind of stereotyped messages for structuring the descriptions, the index data, particularly standardized formats. However, the use of hueristics is not that well developed in recognition of information so most of the work to date, of course, in meeting this dream is simple mechanical sorting. But there is another aspect that I would like to mention, aside from the use of the computer to generate the indexing and cataloging data; this is the availability of indexing data to an individual campus from national sources and I will return to this particular point later. This provides the indexing data in mechanical form available for computer processing but not the use of the computer for the actual development of it, and part of that is the introduction of availability and location records, as in a union catalog, as part of the mechanized indexing and cataloging data.

The third part of the dream is to have the kind of computerized dialogue which is implicit in the CAI type of approach. This, of course, is similar in form to the process of indexing and cataloging in that it uses a glossary and some kind of stereotyped messages for carrying the structure of the information-bearing elements. Added to this, however, is the possibility of tailoring this dialogue to the individual, using special microglossaries, as learned from the way in which he utilizes the computer for interrogation and the like. That's also part of the dream.

The fourth part of the dream is to use the computer or mechanized data forms to mechanically organize, file, and locate. Now, admittedly, this is related primarily to the internal efficiencies in the operation of the library; that is, we want to use equipment to organize the files mechanically, to locate data within the files because it's efficient to do so. If we're dealing with mechanized data forms such as magnetic digital or photographic digital or images in either form, either magnetic or photographic, this becomes an essential. We ought to be able to locate this mechanized data. In addition, however, separate from that is the possibility of automatic warehousing of books under computer control, perhaps. There has been a considerable interest on the part of libraries in compact storage, usually based on some kind of preconceived use studies, so again perhaps the computer is involved here in determining what should be the proper allocation of space to different levels of material. Finally, in terms of mechanically organizing, filing, and locating, we have the possibility of cooperative efforts among different campuses with the allocation of responsibilities for particular areas. To what extent the computer might be involved in this is not clear insofar as it helps in locating the availability of material. But if we do have this kind of cooperative effort where individual campuses in a university system take responsibilities for collection in particular areas, the cataloging in those areas and the like, we're then faced with the problem of remote transmission and reproduction. This, then, is the fifth part of the dream, that the books are not necessarily stored at the point of utilization but rather are stored wherever it's appropriate, and then we transmit in some mechanical manner. So this leads to a national network concept for transmission of high-resolution images, for viewing and reproduction at remote points, viewing through cathode ray tube displays or reproduction through telefacsimile or telezerox reproduction. So that's the fifth part of the dream.

The sixth part of the dream is that if we can have this material in mechanized form we can call not only for the retrieval of books and book material, the contents, but we can also provide some mechanism for analysis as well. At the simplest level, the concordance. At higher levels, perhaps statistical analyses and even recognition of information, contents-bearing elements.

Finally, the seventh element. We go back in history and we have to talk about the Memex, the concept of the individual scholar having in his desk the world's collection of literature and perhaps this is a replacement of the book or a different form for the book, the personalized file for the individual scholar. Then the question is whether the books in the library, whether in book form or in mechanical form, are not the raw material for a production facility. We don't perhaps need to talk about providing the scholar with all the world's literature in this little black box sitting in front of him, but perhaps with a collection of a million pages, tailored to his own particular needs. And if the collection which he now has is not adequate, we use the library as a production facility to create the extra 10,000 pages that he needs in some new area. Added to this is the possibility, implicit in the CAI concept, that the computer might be a control mechanism for his little black box so that, instead of building into his own Memex all of the control circuitry, all of the search circuitry, that the central computer on the campus provides the indexing ability for his file and controls his file for the location of the pages of immediate interest to him. Well, there you have the dream. I think it's one we're all familiar with. It's been recounted a number of times in a number of different papers and even in projects.

Having defined the dream, we have to ask several questions. First of all, what is the state of the art? How much of this dream is feasible and how much of it can be put into operation within some reasonable time? From the standpoint of hardware, the impression which I have is that feasibility is not the issue. The hardware for mass storage is here, perhaps not the magnitudes we might want, but certainly for the intermediate steps in getting to this dream. Certainly the computers are here. The fact that we can talk about a CAI operation, with its on-line capabilities, the third generation equipment, certainly implies that everything that I've talked about in this dream is feasible. The teleprocessing is here. The displays are here. Perhaps the displays don't have the resolution that we would like to have, but again, for the intermediate stages in this dream, I suspect that their resolution is adequate.

Well, that's the state of the art in the hardware; how about the software? Of course, here it's clear that this is much more dubious. The dialogues are still at a fairly primitive stage. If the dialogues include stereotypes, I think these stereotypes are just beginning to get defined. The heuristics in text processing, in information retrieval, have been experimented with but are operational only at the most primitive level. Language processing is, I think, also at a most primitive level. At most, we are dealing with the establishment of standardized vocabularies and then providing table take-up against the dictionaries for translation from my language to the standardized language of the computer. Now this isn't to say, of course, that the state of the art isn't going to progress, but rather that the present state is such that the dream is still pretty much of a dream, except at a very limited level.

The third state of the art issue is even more dubious and this is the area of application and here we're dealing with practicalities. Issues of economics, establishment of requirements and the development of operational systems for book material are all very much on an experimental basis at best.

Well, having tried to set the stage, I would like to raise specific questions and issues and comments concerning this dream which occurred to me which I think have relevancy to what we may say here today. And I will again divide these questions and issues into the same seven categories which I've just raised, but I won't put equal emphasis on each of the seven categories.

The first part of the dream was storing in automated form. I think it's evident that this step is already taking place in the report and journal literature, at least if we're talking about image storage. Witness the NASA present operation on report distribution, the plans of the Federal Clearing House, and the plans of the National Library of Medicine as representative of this. Now, of course, none of these involve storing text in digital form; they all involve storing the page images in usually photographic form and, admittedly, they are limited at the present time to the report and journal literature but these do represent the intermediate steps that we would need to go through. This carries strong implications for a change in the nature of library operations because it involves the introduction into the library of a production printing operation. To an extent, in fact, libraries are already undergoing such a revolution as a result of the Xerox impact. Many libraries are already regarding their collections of journals as noncirculating and that when the request comes, the free Xerox copies are provided. Well, unless such a direction, in fact, is adopted, I would like to suggest that there are real questions based on library experience with microforms about the acceptance of the mechanical storage of books by the scholars. The lack of an adequate handreader, perhaps, has been the source of this difficulty, but there are other things such as the problem of carrying several pages simultaneously in view, the quality and readability of the automated record, the impersonal character of an automated record, like it or not, this psychological content is there, Well, all of these in the past have contributed to a lack of direct usage of mechanized forms, even when they were available. In fact, we must even ask whether the experience with microcards and microfilm is not symptomatic of a basic problem. Is it simply a technological one which new equipment will solve or is the psychological response a valid one? I'll return to this later when I consider some of the approaches to filing which have been proposed. We must also ask what material is appropriate to nonselective prior mechanized storage of text; in other words, if we are going to mechanize the storage of text, what material ought to go into it? Are we dealing solely with scientific material, for example? Is this the kind of text we photograph in microform or put in digital form or do we include scholarly material in other areas, the humanities, and how about rare books? Should we talk about microfilming of rare books? Should we take this as a program on a national basis and put rare books into microform? We have to ask what are the relative economics of different forms of publication, i.e., is a book something that, on an economic basis, should go out of existence? Should it all be micro-image and how much of it, perhaps, should be digital? Particularly we would have to examine this question in terms of the different kinds and amounts of usages; that is, if the library becomes a production facility for printing books on demand, what volume are we dealing with and what form for initial storage would be most appropriate? If we're talking about nonselective prior mechanized storage, in other words, putting all the collection of journals in or all types of book material, what about quality control? It's continually raised as an issue about journals. Not all the contents of journals is worthy of recovery. How is selectivity to be applied if we are to do it, and of course we have the issues of the propriety of information and of copyright all raised as a specter by the image of the library as a production facility.

Finally, I think an even more basic issue is will the libraries have the technical and administrative capabilities of acquiring, receiving, and processing such forms of material? Libraries have had difficulty in the past with nonbook media, and I don't think necessarily because they're backward in some sense. Rather, there are some basic difficulties in handling nonbook material. Will these arise if we try to put book material in mechanized form? Well, these are the questions which occur to me about that one aspect of the dream, namely the storage in mechanized form.

Let me turn to the second area-mechanized indexing and cataloging. To date, this has been operational only at the most limited level, except, of course, for the speculations and experiments. Specifically, the use of the computer for the printing of catalogs and indexes and for sorting on words. The best example, perhaps, is the Quic index, but it takes other forms. The large-scale experiments with statistical indexing with which

I am familiar indicate that costs, if we limit our consideration to costs, are substantially higher than human indexing would be. I won't comment on the relative quality but simply on the relative costs involved. The justification, therefore, for mechanized indexing, if that's true, seems to be that the volume of material precludes using people. That is, we can't index at the depth that we want to, not because it would cost us too much, but because we just don't have the people to do it. Where there is significant time pressure, this may be a valid point, but it seems to me that we could consider as well methods of allocating human effort so that we can focus it in areas where it's worthwhile. For example, we have the techniques of brief listing which are mechanical in character, the key word in title or abstract, and similar nonheuristic methods, which allow human effort then to be directed at the proper screening during output, so we're not as selective in our description, but we can limit our efforts of description at the time of output in the screening operation. And perhaps even at that point in the deeper indexing of the material which apparently is of value.

Well, it seems to me, then, that over the immediate future the real gain is in the utilization of national sources of mechanizing and cataloging data -- The Library of Congress, when and if they mechanize their cataloging function, The National Library of Medicine, certainly, this is well within the plans that they have, the Federal Clearing House, Chemical Abstracts, Biological Abstracts, Historical Abstracts -- all of these as they go to the use of the computer in the production of cataloging and indexing records, in the printing of their own publications, are simultaneously providing us with the raw material for each library to acquire and provide mechanized ability of searching indexes. Again the issue must be raised: are the libraries technically and administratively capable of accepting and utilizing this form of catalog and index? The answer is pretty much no, they are not at the present time. Technically, we don't have in libraries the programs to accept and utilize mechanized sources of data. I'm talking about indexing data now, and administratively, there are some severe problems. The amount of utilization of the computer is relatively small and how is the library going to be charged then for the amount which it undertakes? How is this to be available to the library? We can speak of using the campus research computer, for example, as long as it's a research project but what happens if this becomes part of the day-to-day operation of the library? Is this research and is this a legitimate function to be met by the campus research computer?

Let me turn to the third area, the computerized dialogue. Recognizing the intrinsic attractiveness of this concept, and certainly it's implicit in the whole CAI approach, I would like to suggest, being the Devil's Advocate here for the moment, that there are economic, operational and practical questions which must be asked. Specifically, is the dialogue necessary as a means of access to book material and could not the printed subject authorities serve the purpose better? Why turn to a console when I could go to a printed dictionary and have my purposes met just as well? Wouldn't printed catalogs, even tailored printed catalogs, (i.e., I print a catalog for Professor A, tailored to his particular needs) be more economical than multiple consoles would be? And who pays for the consoles, anyway? Do you provide them only to those few with the grants to support them or do you provide them to every professor? Do you allow every patron in the library to use one, and, if so, how many do you need? If not, how do you provide the catalog data to him? You're forced to go to a printed form in any event. The advantage claimed for the dialogue is that the user can directly communicate his needs without the use of an intermediary, the reference librarian in this case. But surely the function served by the reference librarian is not that trivial. There are legitimate judgmental factors involved in the definition of requests and in the search of indexes and catalogs for available material. Well, these are the comments that occur to me in terms of the computerized dialogue.

Let me turn now to mechanized filing. From the days of Fremont Rider in the book THE SCHOLAR AND THE FUTURE OF THE RESEARCH LIBRARY, the possibility of microform, mechanized filing has been a consistent thread in library operations and in engineering developments in this field. I ask you to recall the rapid selector, the minicards, the RCA video file, the AVCO high-density photographic plates, WALNUT thermo-plastic recordings, photochromic recordings. The variety is great and I've chosen these names deliberately to demonstrate that the degree of success has been equally limited. The more extensive the aims have been in these forms of storage of book material, the more limited the degree of success has been. Indeed, I think it's been a rather sorry picture. Yet, the pressures on libraries are becoming almost unbearable and we look to compact storage, to frequency of usage standards, to cooperative allocation of resources and to shared facilities for relief from this pressure. And here, too, the degree of success has been quite limited. For example, of the half dozen methods for compact storage, that is, putting the books into a smaller volume than they are now stored, only one seems to be an unqualified success and even it's economical only if the building costs are high enough. Shared facilities for little used materials have been recently worked with and usually involve some degree of computerization for the publication of catalogs and lists, and these are still experimental and have been of limited success to date.

Let me turn to the fifth area, remote transmission and reproduction. There have been a number of efforts to allocate efforts in the acquisition and cataloging of material and, of course, this immediately raises the need for remote transmission. Yet here again, all studies by libraries raise operational studies, and there are many of them, i.e., studies in an operational environment. These raise grave doubts about the economics of such transmission, not due so much to the cost of communication lines and terminal equipment as to the manual operations at each end. Usually it turns out that copying the material and then mailing the copies is the only economical choice available. With respect to the last two areas that I mentioned, the analysis processing and data reduction based upon books, mechanical forms of the book, there seems to be little question as to the value of such approaches in research, and if the textual material is in mechanical form, then obviously we are able to apply them.

With respect to the personalized files, I suspect that this awaits only the feasibility of the other aspects and certainly it is a long sought culmination of this dream, to provide each scholar with his own personal, huge library. Well, my intent this morning, then, has been to introduce this topic and, by doing so, raise what seem to me to be both pragmatic problems and also possibly some research topics, that is, areas where research needs to be pursued. SMITH: Thank you, Bob. You've raised a lot of questions and also raised a lot of hopes, I would say. The problems and the dream are both in clear stated form. I've asked Dean Richard Snyder to be our recorder for this morning, and we will proceed with suggestions of areas raised by Bob Hayes which you would like to explore further or upon which you would like to comment, or other areas, too, which were generated by the talk. LAMBE: I would like to talk about numbers, data rates, total information content, present costs and possible costs for this kind of handling.

LICKLIDER: I would presume Bob should add an eighth category. I don't think it's true that the ultimate is the personalized file of all the information one mind can encompass but rather I think that intellectual activities are community activities, at least team activities, and I think increasingly activities of the whole team of colleagues have the character usually of being distributed over the face of the earth and not all brought together in one institute. In this sense, the concept called the "on-line intellectual community" geared to networks of computerized systems might be an eighth category. FISHER: I'd like to have some discussion on the question of a natural language approach rather than these stereotyped means of approach.to the users of the computer system and the computer system itself. MILLER: Bob, you were very cryptic about why you considered the present forms of condensed storage inadequate. I wonder if you would expand on the evaluation of these different techniques, what you think are good and bad about them? You mentioned only one which was entirely satisfactory. I'd appreciate some expansion of this area. SELFRIDGE: Have you made any studies about the present practices of browsing? What people do about it; what they gain by it? KEARNS: You made a statement when talking about dialogues where the printed form might be better than the terminal. Recently an article I read about Florida Atlantic University stated they were concerned about the costs of turning out book catalogs and they thought a solution might be to go to such things as terminals.

GERARD: I was intrigued by your raising the question of allocations of resources to do these various things in the library area. I have been watching from the sidelines a potential major collision in handling of information, administratively at least. The library is an institution which has grown from the book as a means of handling information. We see growing up in all areas now new technologies of information-handling which are extra-library and handled by different groups in different administrative positions, and I foresee either a major war or some kind of a wise resolution of this. I would like to see some discussion of this large problem. BARRUTIA: The tangent to that would be: where does the responsibility for translation lie, when and if we ever get machine translation of text by computer? At the library level or some other level? STOLUROW: I would like discussion of adaptive models relating to the tailoring of the material supplied to the user or requester. JUSTICE: That was what I was going to ask, too. I know IBM has been conducting an information dispersal experiment within their own company and perhaps one of the IBM people here could tell us a little more about the present status of that experiment. Perhaps this is part of this afternoon's session, I don't know. SMITH: Do we want to talk about that? Lick and Bob can decide whether that's appropriate for this morning or this afternoon. LICKLIDER: Let Bob give it if he likes. HAYES: I'll talk about it with respect to one area, that's all. WILLIAMS: You mentioned in discussing the storage in automated form, your first point, that this carries strong implications for library organization and that as the library gets into being a production facility as one of its major characteristics, I gathered that you were pointing this out certainly as one of the problems. But I'd like a little bit more discussion, about whether this is a defeating one or to what extent it would be, or can we simply have a different concept of the total library status as we move into this direction? FLOOD: I think I'm extending the remarks about the adaptive personalizers, but let me say this in another way or at least get this on the agenda. The discussion recently took the form of the passive versus the active library. The idea of the library causing someone to get something he ought to see whether or not he knows he wants it is what I mean by the active phase. The reason I want to talk about it at the moment is, continuing my radical remarks of yesterday, my own feeling is that, more and more, the library will become an active thing, so that we can hardly tell it from the teacher in the near future, where the idea of bringing information to the student because we think he should have it becomes more an active library problem than a correctional problem or a teaching problem. DAVIES: I would like some more elaboration on this question of quality of reproduction of material. I think that it relates to what we were talking about yesterday. I don't think it was discussed enough. For instance, can you look at a cathode ray tube for a long period of time without your eyes getting tired or, if you get a Xerox copy, even though you can read it very well, do certain things happen psychologically after you've looked at sort of a dirty piece of paper as opposed to a nice clean piece of paper for a long period of time? GRUBB: If this question is more appropriate for this afternoon, I suggest we might consider it then, but a number of us raised the observation yesterday that one of the largest bottlenecks in other areas such as CAI is certainly the segmenting of materials to get them into the computer in an instructional model. One of the comments in the dream analysis, here, as you mentioned, is the analysis of content. I was wondering if we could have some further discussion on some imaginative new techniques that would help the author-researcher in looking at automated instruction? Such things as collapsing other subject matters into a summarized form so that a team of people could get this into, let's say, a CAI system faster than the present bottleneck in which we're jammed. GERARD: Since nobody is waiting for an immediate problem, I would like to follow up on the point that Davies raised yesterday. The invention of writing, particularly the alphabet, was a very major social invention. It came long after the ideogram and that long after more primitive kinds of writing, but it's been with us for a very long time now. There are many stirrings such as this that maybe some new type of communication through symbol is going to be possible and is likely to develop with the aid of the newer kinds of technology. Maybe sometime we won't have to read in the sense that we read today. LICKLIDER: Well, I've been wondering how anybody could exceed Merrill Flood in degree of radicalness and then something you said, Ralph, gave me the thought and seemed to let me try it. Perhaps you might give us a thumbnail prognosis on the subject of direct memory logic of human memory. The thing about computers that endears them to many is that you can teach them simply by loading a magnetic tape full of information into the computer's processible storer and it would be interesting if that could be done to people. GERARD: There are at least anecdotal reports of human memories that have essentially the attributes of computer memories which are ineradicable, enduring and everything put in there remained there for a lifetime. I'm not in a position to vouch for the authenticity of them, but some of them look fairly impressive. There's one story which I heard many years ago, that I've never heard refuted, of a man who had laid a brick in his youth in a wall and who had such a memory that when he was asked late in life when that wall was about to be torn down if he could describe the surface of a certain brick in it, he did. The brick was then revealed and his description was correct. I mean, the certain bumps or cracks or whatever. Now if that kind of thing is possible, I think that's about all a computer can do. The problem of how to induce this kind of capacity where it is not patently present is a very different problem, and I am not aware of any really important ways of enhancing memory other than the simple associative devices. I do not believe putting things in while you sleep and so on are very effective. MILLER: Well, since it's understood that we're being far out, perhaps it would be worthwhile spending a little time thinking about DNA and RNA. The recent flurry about this, of course, has been highly controversial, and yet there is some indication that memories are stored in RNA. A book came out about two months ago which, for the first time in print had the entire code of the 64 characters of the DNA and of the RNA code. If it should be true that it is the RNA rather than the lipids or some other substance in the brain where the memory is stored (it has to be stored somewhere), then we're getting along somewhere in understanding the code, which is the first step. About a month ago, the first sense DNA, as opposed to nonsense DNA, was synthesized in vitro. This was considered sufficiently important that it got mention on the TODAY show. This means that the genetic molecule of the virus which is an actual species of virus, has now been created. If this is the beginning of the creation of specific DNA and RNA molecules, as some people think, then it's entirely conceivable that one might ultimately be able to print into such molecules any message, including stored information that you want, by some chemical process. More recently, Allen Jacobson at UCLA and two other investigators, one group in Denmark, have reported the transfer of specific RNA's by interperitoneal injections. This makes no sense to any biochemist I know, as to how you're going to get the specificity of RNA from the peritoneal area up to the brain, but they contend that they have done it and that the animals injected are able to demonstrate acquired learnings of maze running and other such activities which they didn't have before. Finally, there is work by Agranoff, demonstrating that puromycin will block consolidation of memory and Ralph Gerard and his colleagues have demonstrated that aguanozine and other substances can perhaps increase the rate of learning. There are two drug firms which are taking seriously the possibility of developing compounds which will increase the learning rate, and one of them thinks that they have a compound that does this in animals. One of these possibilities is that you can help in the memory losses of the senile and perhaps in the mental retardation by developments in this general area. Now all this is far out and yet there are reported in Science magazine and elsewhere highly relevant research. LICK: Thank you very much. I just didn't want Merrill Flood to be lonesome. FLOOD: While we're on this biological track in a way-out direction, I wondered if somebody might comment on some of the other things. I think the ones that Jim has talked about are somewhat suspicious in every case -- they may or may not be true. There are many things going on in which people are increasing the rate at which things are learned other than the biological-chemical. I wonder if there is any discussion of that problem? GERARD: When I answered Lick, I was talking about your memory. There is no question one can enhance learning, which is a little different from improving memory. One can do it by as simple a device as enhancing the power of muscles by exercising. There is no doubt at all that appropriate physiological functioning of the brain and the nervous system enhances its capacity to function as is true for every other organ, including actual hypertrophies which seem to be demonstrated. I do think our chairman is right. We shouldn't pursue this further, but since it's in the record, let me make a small correction.   of learning inhibit the memory duration, interferes with fixation. Malano-nitrol di that enhances it, you just mispoke, Jim. SMITH: Bob, will you pick up any of the questions that were specifically directed to things that you had said? Some people wanted expansion of a point or two. Others wanted to know your solution to a point or two. HAYES: The one that was of most immediate interest to me was the one raised by Gerard about the administrative issue and the apparent, let's say, competition which is evident in who is going to control the information forms of the future. SMITH: You mean the collision which he described... GERARD: I dramatized it a bit, but I do see some potentially very bad in-fighting unless this gets resolved. HAYES: I think this in-fighting has been evident for some time and is a significant issue in the handling of book material as well as other forms. My own reaction is following: when an information activity becomes operational and we are faced with the day-to-day issues of acquisition of the material, providing the service in whatever form it may be, we will find the necessity of a library-type of operation to be involved. Now until that time arises when we're talking about an experimental application, when we're talking about research in the hardware or the information-processing itself, then this is an engineering activity. So it seems to me that the conflict or the collision is there only if we fail to recognize the proper roles of those who are studying and developing hardware and software and those that are concerned with the day-to-day operational problems. I would suggest that the conflict be resolved, and maybe it involves doing it from this point on, that the libraries be considered as the operational entities and that as the capability is developed, it be placed administratively and operationally within the library. The interests of the engineers in the development of hardware and those studying the use of the computer software in processing would then utilize the operational data base built as a research vechicle but would not be responsible for the day-to-day operation. GERARD: May I push you a little further on that and I hope some others will take it up. One does have developing under independent administrative channels computer facilities, resources of all kinds, on most campuses now which are quite separate from the library. So far, these computers have been used in ways that did not really impinge much on the library function. They are soon going to be used intensively in ways which very violently will impinge on them. I don't think that merely a statement that this, after it is established, can be taken over by the library is going to be enough to bring about a smooth transition, because here will be the information in the kind of storage which does not involve books and techniques of mobilization which do not involve library skills. I wonder in terms of the future what a librarian or an information man or a computer man (I don't know what word is most available at the moment) is going to become, because of the sort of people who are attracted in them in the next generation. This will depend a good deal on what the image to the young people is as to what going into the libraries means and what going into computer facilities means. At the moment, the library image is quite a different one from the computer image. The kind of men going into information science, computer work, I suspect are quite different in their background, perhaps in their basic capacity, from those going into the library. I'd like to see the thing resolved in terms of the kind of people who move into it which will lead to an administrative resolution inevitably. I'd like some discussion on this. HAYES: Well, I'd think perhaps some others would want to comment on it as well, but let me comment in this way. The use of the computer does not necessarily imply that the library operates or runs the computer. That is, the campus computer facility is an operational problem in and of itself. On the other hand, if we are in a day-to-day acquisition of magnetic tapes and microforms, if we are in a day-to-day answering of needs for information in publication of indexes, of production of copies, of book material or journal material, we're faced with a need for personnel which is not like that needed for the operation and running of the computer facility. In other words, for the library, the computer facility becomes a tool to be called on which the library does not itself need to operate, in fact it would be inappropriate for it to operate. MILLER: Apropros this, I'd like to note in the records that -- if we are going to have a centralized computer facility that will operate a number of the university-wide functions that we'll be discussing at this conference, I'm sure the administrations are going to have to face up to the very sad fact that these computer facilities are going to have to be in duplicate. If you are operating a library, you can't have the sort of sad breakdown that Dick Atkinson was complaining about. It's even more true if you are operating the management of a university hospital and all the patients' orders and medications and so on are recorded. You have similar problems if you are dealing with student records and administrative processes; throughout the whole range of university functions, we must get into a different magnitude of continuousness of function and lack of breakdown or we will have a shambles such as the blackout in New York demonstrated last night. LICKLIDER: I'd like to agree with everything but one that Jim Miller just said. He used the word duplicate. I think perhaps the formula might be a little different, and the central computer might consist of many processers and many memory banks, arranged so that if one or more components go out, the others simply take over. MILLER: That's what I really was talking about. FLOOD: So that the whole thing wouldn't fail, like the electrical blackout last night. BLAKESLEY: I have to amplify Miller again in when he said on two or three occasions at Purdue on the first day of classes, things weren't organized. Luckily, that night it was on-line and we were operational the next day. The power plants are very similar. We operate with firm capacity, which means that if the large boiler goes out, we have adequate capacity to keep everything going. That must not have been the case in New York, but we again run into capital costs of millions of dollars to duplicate this, so the thing like Lick was talking about would be very apropos. GERARD: I hate to have this dropped with no more thoughtful comment than that one has to have the facilities work. FLOOD: I would like to both add a little bit to the agenda and make a comment. I thought what Ralph was getting around to is the sort of head-on conflict that I can see developing between the many specialized data centers in the library system. I'd like to see that included in the discussion. I'd like to make one remark on it, that I think we have a very great unique national opportunity now to resolve that conflict in the near future, because of things like the Heart; Cancer; Stroke bill. If we start building lots of that sort of special data centers, which might be viewed as special libraries in some of their contents, without the proper integration of the two, we lose an opportunity. HAYES: May I comment to that, specifically. In the case of UCLA, we have not one of the centers that would be involved in the Heart; Cancer; Stroke situation, but one called the Brain Information Service under the sponsorship of NINDB. This has been designed from the beginning as an integral part of the biomedical library, and when it becomes operational, it will be administratively within the library. Now this is concerned with not data, but references to journal literature, and is an extension, therefore, of normal library services. Its use of the computer, then, is as a tool to aid in the providing of the library services in the better, more tailored form. There is an element of scientific involvement in the review of the indexing philosophy, in the close integration of the dissemination operation between the library and the scientific community involved, in the use of this to support the review process which is conducted by the scientists themselves. But from the standpoint of the operation of the information service, this is not regarded as a scientific activity but rather as a library activity, and the library's use of the computer is simply as a tool to better perform this function. Now there are other kinds of data centers, i.e., metropolitan data banks, survey research centers, similar sources of socio-economic data which are being established on university campuses. Here again our plan at UCLA is that as an operational entity, this be located in the library, so that the service from the data files (this is the data base system) would be provided by requests to the library. The use of the computer is now a requirement because the data is all in mechanized form, but it would be a usage by the library for the purpose of providing the data requested. Now as far as the processing of this is concerned, the statistical analyses and the like, this may well be handled through the library as part of the request or it may be handled as a relationship between the investigator and the computer facility. That's not resolved at this point. The desirable thing, I think, would be if that could be made a single point of contact for this type of utilization, i.e., where we're dealing with a data base operation, but I can't say on that. There are other kinds of data banks and information centers. The ones that occur to me are the materials information centers, the Air Force and comparable ones, which have grown up completely separate from libraries and probably will continue to be so because there is a degree of vested interest in the operation of them. I think, however, within the university environment this would be a mistake, that you're not utilizing the resources in the best way that they can be. CORRIGAN: In looking at Gerard's comments regarding this head-on clash that appears might be coming down the line, I think it raises the problem actually of a requirement for considering completely new system management models for universities which are more appropriate to the objective of managed learning or managed instruction, which is a prime function of the university, in that the role of the library as it can function in a variety of ways to serve these objectives and the commitments of the administration groups of a university can and will change focus, depending upon the reorganization and restatement of how a university can operate most efficiently in the future, utilizing all computer facilities, the library being one function of the total capabilities of that computer. For instance, Oakland Community College at Union Lake, Michigan, is a university totally committed to the criterion of accountability. They say they are responsible and hold themselves responsible for the achievement of learners; they've evolved a whole new concept of systems management in the sense of the function of faculties, the function of administration, the function of libraries, which is very, very closely aligned to the kinds of things we're talking about. I think this a very underlying issue. You can't just talk about a subsystem in isolation; you have to relate it to the totality, the objectives of that system, and whether we want to recognize it or not in that light, that is where we're eventually going to end up in terms of our compromises. MILLER: I think often the name that one gives something determines one's attitude toward it and its goals and in a significant way, it may seem superficial but I think it can have importance. Therefore, it seems to me that new campuses and new universities, perhaps even established universities, might consider using the name "information center" rather than "library." Not that this will do away with books, but rather than it will mean that the comparative advantages of the different information processing media will be more likely to be evaluated in terms of carrying out a given function, and it also means that it will become more natural to include these special data centers and data processing activities with the books. Furthermore, the director of an information processing center, an information center, has a different sort of stamp on him than does the director of the library. Just this terminology may result in a gradual reevaluation of the methods of doing things over the years.

LICKLIDER: It seems to me that this is a very important line of discussion, but I'm embarrassed to realize I don't know which the two forces are between which this collision is expected. It seems to me there are several forces in this case. There is the library -- the extension of the classical, conventional library. There is the computer. There is the communications system, the extension of the telephone and digital transmission. There is this force that arises because stored information doesn't do much good in the world unless it comes into interaction with intelligent processing which is by and large done by people. So one finds the specialized, technical information, analysis and evaluation centers, to give them their full name, springing up. No, not just springing up, because there were at least between two and four hundred a year ago in the United States, all supported by the government and/or one agency or another. These have to get close to a laboratory or an active working place with scientific and technical minds, because it's just impossible to pull creative spirits away from their substantive work. So these things are run on the basis of a ten or 15% commitment for people who are mainly engaged in substantive, scientific or engineering activities. Well, there are other forces, too, but which are the two that are going to collide?

SMITH: We'll start this session, which will last somewhere in the neighborhood of one hour, with a couple of specific questions which were directed to Bob Hayes, the first one being the fact that he had mentioned one form of condensed storage which he thought to be superior to others and he did not name it and he was asked to do so. Bob, would you remark about that? HAYES: Yes, I'll have to back up and define very carefully what I am talking about when I say compact or dense storage. Basically, this is just getting more books into the same cubage. There have been a number of pieces of hardware developed and they are evaluated in a recent article. I can give you the reference later. Basically it's a modular sliding shelf approach which has been used in Europe apparently successfully but which has not been adopted in the United States very widely. Whether the costs of these sliding shelves are warranted (they are semi-mechanized, motorized) is debatable; as I say, unless the costs of building construction, according to this one study, are greater than $25.00 per foot, it's not economic. So that was the specific mechanization--a form of sliding shelf which allows for compacting of the storage of books. SMITH: Another specific, Bob. It's a combination of questions, one from Lambe, one from Kearns, about costs, numbers, rates, at which data is processed and printout costs versus terminals, whether or not the printed catalogue is economically feasible. HAYES: This is according to the Florida Atlantic University studies. First of all, as far as costs and libraries are concerned, these are very difficult to get because no library in the country has a continuous cost accounting system. It is a great lack. Why don't they? You can say that they're just backward, but I don't think that that's really the factor. They're dealing with a product which involves a high level of qualitative content, judgmental factors and quality of product, which is hard to quantify. Also the cost of the cost accounting system itself has been such as to preclude its installation. Now hopefully, this will be changed, but that is the fact; it is virtually impossible to make a direct cost comparison of mechanization with present ways of doing things because you don't have costs on present ways of doing things. Another thing is how the costs of mechanization themselves are accounted for. In one example, I know, these have been counted as part of supplies and expenses, in the budget, to the point where it just doesn't make sense. Even though it may be more economic, your budget is suddenly thrown out of kilter. These are the facts of life as libraries are presently administered. Now as far as Florida Atlantic University is concerned, the cost comparisons were probably made with an evaluation of what it costs to produce a card catalog in some hypothetical sense as contrasted with producing a book catalog and whether it shows up uneconomic or not is a matter of how many card catalogs you're going to talk about producing, whether you regard the book catalog as an added service or as a replacement service, and it's difficult in either of those services to make a comparison with a console. So I really can't answer that, except to say that Florida Atlantic University's experience is not based upon a long-standing library. There are built-up costs involved there as well as a learning process, so it's very difficult to make an evaluation. Now in talking with

Ed Lambe at the break time, the reasons for his particular question were raised, and I would like to comment on them. The dream which I presented and the feasibility of that dream is, really, the question which I think he had in mind. Although it may be technologically feasible, the question is whether it is operationally feasible, i.e., how will the costs compare with the present costs of operation? To state my own belief or opinion, which is based at this time on no facts, the concept of putting the entire library into digital form or the entire catalog of the library into digital form, will not be operationally feasible even though it may be technologically feasible. Given the technology, there are better ways to use it than to put the entire library or the entire catalog into mechanized form. I may put some portion of it into mechanized form, and the problem, operationally,then, is determining which portion goes into which form, so this is what I was referring to when I mentioned the fact that the application area is still undeveloped, even if the software and hardware is developed. LAMBE: I wonder if I could pursue that just for a moment, because it seems to me a very important point. The reason that I raised this with Dr. Hayes has to do with the fact that I've made a calculation which made it look as if one needed a 10 or 12 or so foot memory, and as I said to Dr. Hayes, I know of only one system in the country, namely that at Livermore, that is even beginning to approach a memory of that size, and access problem to it is far from solved. There is another aspect to this, however, which seems to me to be quite important and that is, whether one could look at the problem of computer-assisted library services in a "project" way to see, step by step, how one might proceed to get into the business, and find out if the things that you included were sensible short of putting everything in digital form. Dr. Hayes told me that they are certain inventory projects which are now operational. It occurred to me if one could striate the operations of the library, in slightly different fashion, to see whether that would help at all, and the striation that I was thinking of had to do with the categories of use of volumes or general activity levels, if you like. I presume, but this is a question, that one could separate the items in a library into things that don't get touched maybe once in a lifetime and other things that get handled almost every day and categories in between. If one did that, one might begin to see if there is a kind of service one provides that is sensible to computer systems. Does that make any kind of sense at all? HAYES: It not only makes sense, but to a large extent, it is being done now. That is, the very concept of compact storage reduces the accessibility of material. You put it in a warehouse, for example, and then you have the problem of getting it out of the warehouse, which is physical access as well as an intellectual access. In fact, this is done. There have been a number of studies and installations made where the collection was broken into parts, based upon frequency of usage, and these have been successful. Now what portion of the collection is frequently enough used to go into mechanized form makes a very reasonable question to ask, and we don't have the answer to it because libraries have not taken the preliminary steps that you are defining. But hopefully we will do so and will define a level of utilization where it is economic to put it into mechanized form. BLAKESLEY: Wouldn't it also be true, though, that if the level of utilization were too high, it would be uneconomic also because of the access to that particular information? HAYES: That's possible. Again, I think this is a question which can be decided as a technical issue: a cost-time analysis, the cost of producing copies, the cost of access for high utilization material. MITZEL: I have a hardware question. I think that's what we're talking about here. Philco and perhaps others have developed a combination system. The storage is on microfilm, the retriever is video, and the control is computer. It seems to me that is a potential solution to the catalog problem where the costs of the storage of information are high but you get the retrieval back rather quickly. HAYES: Ampex has a video file which apparently is operational. That may be what you're referring to. Philco may have comparable things. RCA proposed it about seven years ago, but they never succeeded, and it was just never built. It's an alternative method, and again I think it's just an economic evaluation as to whether it's applicable or not. One trouble has been, particularly in the area of image storage, that the number of projects and devices proposed has far exceeded the number which ever appeared, and the claims made for those which did appear were much greater than the actual production rates which arrived. Another point which has to be recognized in the library is that the library in the past has suffered under fantastic economic restraints. It has not been regarded as a high budget item, and there isn't a library in the country which would compare with even a small-sized business in terms of its total budget. It's just the facts of life. It's a low budgeted area. Maybe this is because we haven't recognized the importance of information and maybe that's changing. But in large part, the fact that libraries have not suddenly moved into automation is a direct result of economic limitations. The budget just hasn't been there to do it. MILLER: Do I understand that in referring to economic considerations you're speaking in terms of a specific, individual university? If it would be possible for universities to combine together in some way and allocate this responsibility would this alter your estimate about the feasibility of making a digital store, say they jointly keep the union catalog or some of the texts? Do you think that it isn't possible on a joint basis any more than it is for an individual university? HAYES: Well, I guess that to answer it specifically, and, I have no data on which to base this, it's simply an opinion or a judgment, it might be possible to produce a single digital store which was the union catalog, but I would use it as a production facility for producing printed catalogs on a production basis rather than as an on-line interrogation facility. MILLER: Just because of cost consideration? HAYES: Yes, just because of cost consideration. In other words, there are more economic ways of doing it. The whole technology may change, but I will merely say that where the tests have been made to test slow-scan T.V., for example, for transmission of image information from one point to another, the costs have not been the significant factors. They have been the fact that someone had to be there to turn the page, for example. Well, one can think of a piece of equipment that will turn pages, but it has to be brought to this and the time involved in monitoring the operation of the equipment at each end has made it more feasible to simply copy the material and mail the copies. An attempt was made several years ago to study the video scan of a catalog so that the catalog could be searched from a remote point and the catalog cards were displayed. Again, the costs of doing this far exceeded the benefits obtained. The results were just completely negative, and this was a study made by the industrial engineering department of ________ University. LICKLIDER: I agree with you, Bob, about the frustrating nature of the economic obstacles, and the fact that the libraries don't have large enough budgets, but it disturbs me when what seem to be the basic economic considerations argue one way, that the frustrations present themselves as obstacles to getting there. Now the fact is that almost all published material is in digital form at some stage before it gets into print. It's true also in science and technology approximately that it would take ten years to get any place to make the social and administrative changes, at which time half of all the information there is would have been made after now. The next ten years will amount to as much as all the past. When it comes to storing this, it's just easier and cheaper to store it digitally than any other way. As a matter of fact, if you project the costs for this device that was mentioned that Livermore was interested in, it looks as though the costs of all the facilities for storing a page of text or printed material will be approximately the same as the cost of reproducing it by one of the common office duplication methods, so that it really is cheap storage, and to do it reliably means you'd have to have parity checking, and to have parity checking of any working kind means you'd have to be in digital form. Now communication gets cheaper when it's in digital form, so my argument is, of all the basic factors don't let it get out of digital form - store it that way, transmit it that way, and regenerate it for inspection. It seems to me the role of leadership in modern society is somehow to break through the frustrations

that lie between where we stand and taking advantage of the way things clearly ought to be done. That's my speech or sermon.
LAMBE: Well, I had one question for Dr. Hayes, but I'd like to ask, why digital form? I take it you include the fact that a typewriter is in a digital demonstration. I mean, you could make the 88 character set as a digital-type procedure.
LICKLIDER: The word terminology here is not a good way of saying what I was trying to mean. The best, I think, is "amenable to computer processing". Almost any image is computer processible in the sense that the computer can scan it, can turn it into binary or decimal digits and so on. By digital form I meant a form which is conveniently stored in a processible computer memory, alpha-numeric, or perhaps in diagrams, even in pictures, but I'd rather not get halftone-like pictures into the discussion yet. HAYES: I interpreted your definition of digital in exactly the way that you've indicated that you meant, and we'll agree that the costs of storing it in digital form and retaining it that way are probably less than the costs of printing it and storing the printed volume in the number of different places where we want to store it. This will change, and this was, of course, one of the parts of the dream. This will change the character of the library as to where this is stored, and it really becomes a production facility. I wasn't criticizing that but rather just saying that this is implicit in doing this, and I have no doubt that if the social and political feuds could be resolved this would be a very appropriate way of going. So I'm not disagreeing with what you're saying. What I am saying, however, is that, given that fact, there are still situations

(and a majority of them, I suspect) in which the storage in book form, because of the other operations involved, will be the more economic. Let me raise another point, however, which has to be recognized about the university library. That is, that the bulk of utilization and content of the university library has been toward the humanities. The university library is, in a sense, the research vehicle for much of the humanities, for much of history, the arts and literature. If you look at the bulk of the contents of the library it's not scientific literature. It's this historical material and it will continue to be so, so that I would interpret what you are saying in this way: the bulk of the scientific literature and technological literature we can obtain in this manner, and the kinds of services you're talking about will be very economic in the scientific fields. That is, that we can provide access to this literature in mechanized form and we can provide a production capability within the library in mechanized form, but that still does not solve the basic problem of the university library in terms of its space, in terms of its service to the university, in terms of the bulk of utilization of it. ATKINSON: I have very little knowledge in this field, but I'd like to get clear on a few points. Isn't it the case that most printing, at this point in time, or at least large-scale printing operations are under the control of magnetic or paper tape operations? LICKLIDER: I think that's approximately true, but don't leap to the conclusion it's all there in usable form in the tape. There are a lot of handwritten notes on the tape and so on. This is linotype and monotype tape. They're not quite to the point where you just use them directly. ATKINSON: But how recent is that innovation in the printing industry? In the last five years at the most, right? LICKLIDER: I thought that was fairly old. It seems to me that I've seen linotype and monotype tapes for years. HAYES: Yes, monotype tapes have been available for fifteen years or more. ATKINSON: What about magnetic operations or controls? LICKLIDER: I'm not sure that's used, but if so... JUSTICE: It seems to me that the trend is more toward photo-offset methods. Although many times the master for the photo offset is produced by Flexwriter techniques, so somewhere along it goes through _______ tape. FLOOD: For whatever it's worth, Mr. Benjamin of McGraw-Hill told me last week, and I won't vouch for this, that at least 10% of the materials that get in the library exist on any kind of tape at the time of referral. This startled me. LAMBE: I haven't yet gotten to the question I originally had for Dr. Hayes, but I would like to challenge Dr. Licklider's statement. You pointed out that information was, at some stage, generally speaking, in a form that was amenable to processing, in accessible forms for a computer. I think that's probably correct in principle, but it seems to me that it omits a very important matter, to take that as a model for perceiving or to set that as an ideal. It seems to me the important aspect it omits is that it's one thing to create words-that goes on all the time-it's another thing to find them in any useful and that, in some ways, inaccessibility of paper is a mercy, a kind of editing process which has to go on and which perhaps ought to take place in a very expensive mode, so that if there are things that are written and forgotten, that's probably good on the whole, and to do something different would sort of weight the whole planet down with rather clumsy storage. LICKLIDER: I'll respond briefly. About weighting down, the form of storage I was referring to is very much lighter.

About being selective, one must figure out how one is going to separate the wheat from the chaff. If you get the material into computer processible form, I would propose a lot of screening techniques that could be carried out automatically and cheaply without ever bothering anybody to read it, that would say, for instance, the syntax or grammar were bad enough, if the spelling was bad enough, if the thing has picked up no favorable comments from anybody, why waste your time? MILLER: Before I make my point, I'd like to say that I can't agree with Lambe on that because I don't like to have chance determine what information I'm going to get access to. I don't like to browse through a shelf where the books that are out and are missing and are misshelved are the ones that I might have wanted to see. I don't think the fact that journals aren't available in the library should determine whether or not I have access to them. I think there can be a science of how to handle information overload. We should learn to operate it as a science rather than depend on chance factors of availability. The point that I would like to make, though, is that all of this discussion concerns input, and I strongly support Licklider's view that we have to rise above our restraints at the moment. If we can't do it as individual universities, perhaps we can do it as a nation. Regardless of whether only 10% of information is on tape or 50%, it seems to me that fundamentally we are bound to be frustrated by the concept of accessibility of the information at source. Not that you have given a good reason, Bob. The law or history are concerned largely with the past. Many of the books and documents in libraries go from the past and are not available this way but also even if we could operate a voluntary system for getting information at the source within the United States, the political and diplomatic problems, the human relation problems involved in such cooperation would be tremendous, and that's just within one country. Around the world it's essentially hopeless. It seems to me there's a much cheaper solution, and that's the solution which you mentioned, the character recognition or character cycling devices. The problem is that these devices aren't yet here in the way we would like to have them. The reason is largely, as far as I can see, that there has been no industrial firm that has seen that the long-range market for these will justify a priority effort for this particular type of gadget. An article in the June 6th issue of Barrons says this flatly, and if this is true, which is reasonable from an industrial point of view, then perhaps universities should speak up or the government should speak up and subsidize this. Now, actually we're pretty close to it. Last week IBM delivered to the Social Security Agency in Baltimore a photoreader that will read 25 different fonts of typewriter type at the rate of better than a thousand characters a second. I have in my possession a letter from Philco Company offering to make a contract to provide in 18 months a character-sensing device which will read any 10 fonts of printed type we would want to choose. This development contract would cost a sizeable amount of money, but still quite reasonable, in the range of perhaps a million dollars. It seems to me this is the appropriate solution. At this moment, Philco is reading daily with 95% accuracy the front page of the New York Times into digital storage at Rome Air Force Base. Now that isn't good enough. You need 99.9% accuracy, but aren't we within a couple of years of accomplishing this? And if we can accomplish it by a little more effort in this particular direction, which may not be particularly advantageous to any industry, but it's tremendously advantageous to the universities, we can begin to solve the problem of inexpensively putting text into magnetic storage. SMITH: I think this may lead rather naturally to another question which was asked, and this is specific, too. Somebody, in talking about the tailoring the information for the specific user, said that there is an IBM model for experimentation at the present time. Is there anyone who knows more about that who would care to describe it? JUSTICE: I was the one who brought up that question. It doesn't relate to character recognition at all, but I'm sure that Dr. Licklider has probably participated in that program. It came about as an experimental program in which IBM was sending abstracts of various articles to their technical and sales personnel in a selected manner and getting feedback from this. I heard about this several years ago, and I think nothing more... LICKLIDER: There seems to be two different things here. One is the character reading and the other is selective dissemination of information. I think we ought to decide which path we're going to follow. SMITH: Well, it was a specific question about selective dissemination. Let's go to that and maybe that would relate to another question which was asked about the active versus the passive nature of the library,because if the library is to be in the dissemination field, it will have to change its character considerably. Who wants to speak to that? HAYES: I'd like to because I did not intend to convey the picture of the library as a passive organization although in large part in the past it has been, and certainly the influence of mechanization will be to make it more of an active one. Specifically, if we regard it as a production facility, then the opportunity is there of producing microform copies for this personal library, not on demand, but as an active production operation and of perhaps providing the individual with a journal which is not in the field of computers but is in his own interest. This could include ten articles from the computer field and three from psychology and so on, and producing this as a journal for him in the selective dissemination kind of mode. If you have the production kind of facility within the library, you can tailor this very nicely. It doesn't have to be digital form, it can be photographic as well and still have the production capabilities. The only question is how much do you provide the individual person and what selectivity do you give him so that from in the flood of material you provide him, he can select from it? I think also the potential is there to use the computer to select among his own material. You've disseminated to him, he's got the copies there, you've made it a production facility in the library, and then you use the computer to provide him with the index to his own material on demand. JUSTICE: The important thing is getting an adaptive or dynamic system that reflects the gradual evolution of his own interest, and this was an important aspect of the IBM experiment. As each abstract card was sent out, he was asked to check whether he wanted the article, and after he got the article, he was asked to feed back information as to how useful it was-whether it really turned out to be useful or not. In this way, they gradually built up a definition of the person's interest and requirements that was continually updated. GRUBB: It seems to me there are many subsets to the problem, one of which, of course, is generating the abstracts which at various phases of that SDI system worked on an auto-abstracting principle; you know key word analysis and then lifting out the sentences that housed the key words from the author's abstract. Some of the psychologists were utilized in developing the effectiveness of such a system. For example, we took many documents that were in machineryable form, like Scientific American, some military documents, and general kind of things such as newspaper articles, Saturday Evening Post, and a variety of things and had humans generate abstracts of those machine-generated abstracts, titles only and these things, and so forth and lists of specific questions. What was really generated was an experimental design by which college students and other users would give list questions, and one group might be given a list of titles with the autoabstract and/or human-generated abstract which they were to read and check where they would find the document that would specifically answer the question. The point is, for many people, the lists of titles was as much information needed for saying they should go to this document to answer this question as was, for example, some of the autoabstracts. So a very important element in the whole system is the quality of the abstract that's generated and does this buy you a great deal more than just the title of the document where you would go to find the answer to your question? LICKLIDER: I think that this was Merrill Flood's question in the first place, and he has participated in one of the most sophisticated of these dissemination enterprises. He ought to describe SADSIS. FLOOD: I was eager to hear about things I might not know about, and I talked with Mr. Stolurow and others during break. First of all, I'm impressed by the lack of work in this general area of dissemination. I feel it's a great opportunity. In a meeting like this, it's dangerous when any of us talks about research in which he's personally engaged. Let me try, as Bob has done brilliantly, to give you a cold-blooded detached statement, so that Merrill Flood isn't the thing being looked at. The passive versus active library, I think is a general topic, and dissemination is just one of many things we could talk about. I really feel very strongly that the active effort is important. So let me just use dissemination as an example. I think that's a great opening for people to find ways to make the libraries of the future active.

First, historically, the SDI system, which I guess is really Pete Newland's idea, selective dissemination of information including the autoabstracting is the follow idea. It's been used a great deal in many kinds of organizations. There are many different versions of SDI. The idea is that you would send to the system a few descriptors. Julian Feldman ran an experiment on this at the University of California ending about a year ago. In the version that he happened to use, we sent in a few words, maybe 20 or 25. In this case, you can only send in the first five letters. Now these little details are important because your object is in 25 five-letter words or parts of words to give the system a portrait of your interest at that time. That itself is an interesting problem and so we all did that. Then the computer looks through the abstracts (not autoabstracts, I think people prepared them) and looked for, for example, an occurrence of any of these words that might send them to you. There are many versions of SDI missets. You can set up a system so you can tell it if any of the words appears, send me that abstract, or don't send it to me unless the three words appear or don't send it to me unless three words appear but these two don't. These Boolean combinations are another part of designing a Pete Bloom kind of SDI system. Well, very briefly, then, the idea is that an individual can give a set of words plus a Boolean operation on them of "ands","ors", "nots", trying to portray his current interest. Then of course in the adaptive sense, as Mr. Justice has pointed out, you can send in a new portrait whenever you feel like it if you don't like what's coming to you. You can tell the system, here's a new set of descriptors, please change, and it'll do that. It's adaptive only in that sense.

Julian Feldman made an attempt to evaluate an SDI system such as I have described it. I came about the middle of the evaluation, got in as a user and was horrified to learn that Julian never used the system himself because it wasn't interesting and useful. His evaluation of the system indicated that, also. On the other hand, there is rather widespread use of SDI. I have been at IBM as consultant, six summers. I used it the first summer or two. Fred Kochen is manager of this work and a very close friend of Pete Newland's, an admirer of his. He used it for awhile and dropped it. The reason is that the hits versus misses problem for these systems is not difficult. We all have too much to read anyway, so another system that send you lots of things isn't very interesting.

Now the next experiment at IBM which I had no part in was done by

Fred Kochen and Gene Long about four or five years ago, to try to find a better way. There are many things wrong with the SDI idea. The idea back of the Kochen-Long attempt was that another way to understand what somebody ought to see is find somebody else sort of like him. So if Bob Hayes said some item is terribly important, there's a pretty good chance I'd like to see it because I have some interests in common with Bob Hayes. On the other hand, I could probably find somebody in some other room that if he found it interesting, chances are not very great that I might if he were, let's say, in a specialty in nuclear physics or something which I'm not interested in. In this room, I'd probably be interested in most things, because I have some common interests. So the DECODE system, as it was called, worked roughly as follows: you have a set of participants. They look over a compilation of articles. Actually, they look at abstracts. I think they used 300 abstracts in the original trial of 50 people and they rate them so item number one is rated by each of the people, rated on a scale from 0 to 10. It ended up being cleared with a scale from 0 to 1, relevant or not relevant, etc. Now you have a portrait of the group and then you take the following idea. If two people have 1's appearing in about the same places with respect to the items, clusters are formed. If, for example, Hayes 1's appear about the same places as mine do, there's a good intersection there, so send me the things that Hayes says he likes. A computer program analyzed these data and it was discovered that for these 50 people there were three clusters with overlapping. This was in the IBM research operation. Henceforth, when anybody in a cluster says to the system, "the following article is interesting or relevant or important," then the system sends that to all the people in that cluster. For experimental reasons the feedbacks were sent back-the persons who got them, sent back whether they found them relevant or not- and Kochen and Long did some analyses of whether or not these things worked, and published some articles on this. There were lots of things wrong with that, and I was brought in an a consultant to propose a next version, which is SADSIS which Lick mentioned and now I'm talking about personal ideas, so I'm careful. Let me mention just two or three things that seem to be wrong with SDI and DECODE. In both cases, you couldn't really make them adaptive. If somebody's interest changes, you could in some sense discover this and make the change, but it's very difficult. And there are many other things. For example, there's lots of information you'd like to use. SADSIS stands for sequential adaptive stotastic information dissemination system. It uses the DECODE basic idea, coupling of interests of people. The essential idea is, that if anybody tells the system he likes an article, meaning he found it important or relevant and so forth, then at that instant there is a probability coupling him with every other participant in the system. If the probability is high, then that is the probability that the other person will receive the item. If the probability is low, then he may get it, but the probability is low. If the other person sends back and says I found that relevant, then the probability coupling the man to him is raised slightly. The model I used is the incidental model. And the other important feature is that there is individual tuning and the individual tunes the data up and down to increase the rate of adaptivity.

I'm trying to stress that this is an attempt to find a way to make a library very active in bringing every possible kind of material because it can be a memorandum, it can be a letter, it can be a conversation and they do all of these things. The idea is for an information system for a set of people which will discover things they should be interested in; for example, if Bob Hayes one day in working in his library interest comes across some little thing in the field of mathematics which he suddenly realizes is very exciting and he says this is an interesting paper then I will probably see it at SADSIS, and that might teach me that here's a whole new idea that I never dreamed of. HAYES: There are a number of points which Merrill has said that are worthy of consideration. One, the Feldman experiment is representative of an issue which has to be recognized. And that is that when he gets tired of it, it stops. Or whenever whoever is running the SADSIS operation as a research project, as a study of how a library can be active, these are great and they do indicate a great deal, but the problem arises of how do you transfer this-the experimental results-into an operation environment so that it doesn't disappear when Feldman ceases to be interested in it? The answer is not a trivial answer because this service must be weighed with a whole host of other services and becomes merely part of an allocation of resources issue. There's a second point. That is that as a participant in SADSIS, I have been very poor, that is, I have not participated in it. I participated in it during the first two or three months when I got the cards, but honestly, the pile of these punch cards has now gotten very high, and it's accumulated for close to nine months if not longer, where I just have failed. I have failed to provide my input to the system. Now this is a failure which hurts me, I suppose, but I think it's representative of what can happen. And that is that an active system has to be designed not only as an operational entity but as one which is to as large an extent as possible, independent of what the person himself is doing, so that you're not dependent upon him. You get your data for your adaptive processing not by anything that you're counting on him doing. Now how do you do this? Well, possibly by keeping track of the material which he actually acquires rather than that which you disseminate to him and then he says yes, I wanted. Alternatively, one might disseminate, and this is the suggestion implicit in the NEMEX concept, a huge amount of material. The scope is much broader, but you provide him now, through the dialogue, with the means of access to this. That's where the real adaptivity comes in, as he uses his own personal files.

In our information service - at the Institute for Library Service at UCLA - we have an active dissemination process but it's not machine-run. It is run by an information specialist who is a member of the library staff, who works closely with a group of about a dozen scientists and essentially must maintain a close relationship with them and disseminate material to them. In addition to this, we provide as a response to requests, the 3 x 5 cards for the maintenance of a personal catalogue, that is, an index file by the scientist, of the material that has been sent to him. The intent (and this is in planning but not in existence) is to maintain his personal 3 x 5 file in magnetic tape form, so that when we are ready to put in a console, he can communicate with the magnetic store rather than having to maintain his own 3 x 5 card file. This kind of dissemination and this kind of active service is not dependent completely upon his utilization. It responds to his demands for information and it introduces a person who can make an evaluation of what the real interests are. From an operational standpoint, I think this is the direction which we have to consider. The SDI approach (where it depends upon the activity of the individual), I think, is bound to fail because of non-participation. FLOOD: While we're in this session of SADSIS users, let me remark that I've never read an article that was recommended to me by the SADSIS system. I have a large list of relevant items,none of which I have ever seen. LICKLIDER: I want to qualify your comment about depending upon the action of the user. I agree with you on the operational feasibility of it - as long as people are off-line it's difficult; but get them on-line and you have every activity, every hunt and peck of the typewriter and so on at your disposal. SMITH: The question was asked about the psychological effects of the Xerox copies as distinguished from the beautifully put-together objets d'arts known as a "book" and what impact this has on people. The Xerox bloodshot eyes. Who wants to pick this one up? HAYES: Our impression from the reception by the scientists is that the Xerox copy psychologically fits the need, provided you don't force it upon him. It does not work to say we will provide a Zerox copy of everything that you ask for, not because he doesn't want to read it, but he doesn't like the economy of it. He's afraid that so much of what he would get he wouldn't want and he doesn't want to waste the money on it. It's strange but this is the reaction we have gotten. But for the material that he really wants, rather than getting the journal, to get a Xerox copy, poor though the contrast may be in the typographic quality and the like, the reaction is very positive. It's liked but I have a very different attitude toward what I think will be the reception of the console, that here the flicker as it is there, the light contrast, and all of the psychological and physiological problems will be as great, if not greater, than they were with the microfilm reader and there the physiological responses are very poor. It is just unreadable after some period of time. I think that this is a real barrier to the implementation of the CRT type of console. GERARD: I'm a little surprised at the direction of this discussion in view of the complaints of most parents that their children sit for an unlimited number of hours watching the CRT. SELFRIDGE: Xerox Corporation would be very happy to receive a development contract to make a hardcopy printer from a CRT. It ought to be possible to get two-second delivery of a high contract hardcopy as you like and the kind of resolution they're talking about is 25 lines to the millimeter, which is far better than the optical system at the present. HAYES: I know Xerox has this on the drawing boards if not actual equipment operating. If we were presented with the image and were allowed to accept it or reject it, this would, I suspect, have a real reception. It would fit the needs of having multiple pages so that you can get your Xerox copies of those pages that are of interest to you and you can make the comparisons among them. MILLER: One word, I think, should be added and this is portability. The CRT is not portable and the Xerox pages are. SMITH: Are there any comments from those of you who have not spoken up here on this or other aspects? Is it too late in the morning, Ralph, to go into your jet-propelled question about our evolution into new forms of symbolic communication? GERARD: If anyone has something to contribute, I'd love to hear it. FLOOD: I was impressed by the forthcoming meeting of the Joint Computer Conference. Rye is giving a serious technical paper on extra-sensory communication between machine and man in both directions. SMITH: The statement was made yesterday there was some discussion of natural versus artificial languages and the questioner wanted more amplification on that question as it related specifically to the paper this morning. Does anybody care to get going on that one? FISHER: There's a lot of trouble with stereotyped messages in approaching the computer. It's hard to remember what the stereotyped form is without a directory and it's very flexible. You often want to ask questions that the stereotyped message doesn't exist for, and natural language has many advantages over the stereotyped form. We're familiar with it, it's powerful and flexible, we can relate a number of previously unrelated items by making a natural language statement. It gives you power to answer unanticipated questions and power to add data when the user doesn't actually know the structure of the data base he's adding data to. It seems to some of us that this is the capability that you really need to make this dream you described come true, that the user can use a language he's familiar with and the power that the evolution of the language has given to it in dealing directly with the computer. HAYES: I have, as a computer person, a great desire to have a natural language communication, but I would then reveal the same position that I've had all along, namely that although I will accept the feasibility of it, I question whether it is a desirable way of operating on an operational basis, and I must always think in terms of an operational basis because, like it or not, this is what a library does represent. FISHER: Do you mean now or ultimately? HAYES: I will speak over the period of time of, let's say, the next five to ten years, that the stereotyped message provides a way of avoiding table lookups, it reduces the complexity of the actual internal processing and provides still a very powerful means of communicating so that from the standpoint of being able to implement it on an operational basis, I have to view it as the stereotyped message that will be the direction taken. DAVIES: I would think that we would gravitate toward the use of natural language through the use of formal languages and stereotyped messages. I think that what will happen is that people will demand enrichment of whatever language they are given, and this will occur through increase in vocabulary and more powerful syntactical rules. JUSTICE: I think the key was already mentioned - the word evolution. The natural language that we're speaking here today evolved as an oral language, as a spoken language and we also have a version of it which we write, but this is not necessarily the language that we should be using nor that will be most efficient in talking with computers of tomorrow. I think we need to evolve our present spoken language into another generation, or another version of the language, which will both suit our intellects and the intellect of the computer. It need not be the type of stereotyped language we're using today and by the same token I don't think it should be the spoken language we're using today. It will be some new version that will be more optimal than either of these. SELFRIDGE: I don't see this great distinction between natural and artificial languages in this context. People talk without having tried to use natural language on computers. You wouldn't use natural language to give commands. This is fine if you're not experienced. As soon as you're experienced, to get a natural language response would be unacceptable. You can't wait that long. At Project MAC we try to have two or three modes of talking and it's perfectly straightforward. If you're uneducated you use one mode and it comes out, and soon you don't want to type "resume", you type "r" instead. This is not very different from natural language either. It's an extension of your vocabulary. It's perfectly straightforward. Certainly any on-line system ought to have several modes of operation in detail. These are feasible now. It's being done now. Presumably, this is absolutely applicable to this problem. There should be several modes of doing it. To receive a two-line message containing essentially three bits of something useful is an intolerable wait when you're actually running. The first time it's passe'--it doesn't take any time, in fact to acquire into your own language the stereotography which is the kind that even people do themselves. DAVIES: I think that what you're referring to as natural language isn't natural language at all. It's a stereotyped language that is disguised as a natural language because you're using natural language terms, so you take in all the bad aspects, the penalties of natural language, namely the redundancy, without getting any of the benefits or the flexibility. I think what Mr. Fisher was seeking were the powerful aspects of the natural language, which I don't think have been incorporated into any of the systems to date. FISHER: That's the point that I wanted to make. It isn't that we use English words. That's not what I mean by natural language. It doesn't matter what string of English words you use as long as it conveys the appropriate meaning so that you can address a computer by saying "log -in" or "here I am again today," or whatever it is that's appropriate to say as long as it indicates that you're there again, the computer responds appropriately. Have you got a question to ask? You want to know an item in the data base? You ask the question as you would ask it of any human being and the computer analyses it, digs out the answer, or if it can't make a go of it, it asks you for clarification, and you get the answer out. But it doesn't matter what particular order of words or particular string of words you use. SELFRIDGE: If it's a question you want to ask more than a few times, you want a short stereotyped way to handle it in any case. If you're going to log-in, and this is feasible today at any time, the easiest thing to do is to type "log-in" which is only five characters rather than "here I am again". TONGE: We want to say extend the vocabulary and extend the syntax of the language, but as soon as we reach that talking to people, we use references, pronouns, unclear reference, and all sorts of things which depend on interacting with the data base for the context in which we operate. In the context of asking about whether programs are available today, I don't see increasing evolution looking at the program from the non-ambiguity, inability to process ambiguous language that we have to what the computer is going to talk about whatever it is you want to talk about in natural language. It may be technologically feasible. Operationally, it's not ten years away; it's more than that. SMITH: We're going to close now this where we began with final comments from Bob Hayes. HAYES: There are three comments I would like to make.

One is a hearty accord with what Selfridge has said about levels of operation and that the system should be designed to function at a whole host of levels of sophistication, hopefully functioning at the level of least sophistication most of the time, that is, at the simplest level. Otherwise, the economy just explodes.

The second point is really a question. Whether we're talking about stereotypes or natural language communication, the problem of the required data rate becomes a significant one, and it is not at all clear to me what the required data rate at these levels of sophistication is. That is, if I wait for a two-line message to come out which involves reading only a three-bit choice as far as I'm concerned, is this an acceptable data rate from my standpoint or do I require something faster? And what is the load that this is going to place upon the communication network with the computer? I don't see any results at this point in time which give us an answer to that.

The third point is a much more limited one and it really is what I think is part of the developmental problem. Namely, for the library and for the recovery of books and the contents of books, and this afternoon, I assume, data banks and data bases. I think this is a fairly straightforward developmental project that we should be underway with right now. SMITH: Bob, I want to thank you. I know I am joined by everybody in thanking you for your paper this morning, for the dreams and the questions. I thank everybody here for what has been to me an educational and edifying morning.

Wednesday, November 10

SESSION IV

9:00 a.m.

CAI - LIBRARY - STORED INFORMATION

Speaker: Joseph C. R. Licklider

Chairman: Robert M. Saunders

SAUNDERS: I call the afternoon session to order. As the first item of business, I will call on Dick Snyder to report as recorder for the morning session.

SNYDER: The first thing I discovered was that I wrote too small. The second thing is -- I'm not sure it's worth going over. I think the title of this exercise might be "If you can keep your head while all those around you are losing theirs, you may be sick." We covered a lot of ground. It reminds me of an old colleague who said "Beware of anybody who starts out with the sentence I'm about to cover, and I'll say some obvious things." It occurred to me that since I might have been tired from listening, I might have been victimized by the third ear phenomenon. I may hear things that aren't there.

The first category I simply called "the impact of computer sciences and technology on social organizations" and it seemed to me that both Bob Hayes' presentation and in his response to some of the questions in the discussion, we got into the impact of all this on the universities. Somebody's going to have to face up to that, and it looks very much as though traditional views won't hold up. Impact on libraries, organization and staff, impact on learning situations as organized interactions, impact on intellectual communities and on university relations. This may be something of far greater importance. I didn't mean this to be a residual category. When I began to add up the questions and comments that went in this direction, it seemed to me that we had a classical instance, if you will, of a large social phenomena that we're living through and it might pay someone to step aside and ask this set of questions much more systematically.

The second category we certainly got into yesterday and we got into it today because of the nature of the topic, and I've simply called this " Alternative strategies, facilities and devices for selecting, storing, retrieving and disseminating information." It occurred to me that a possibly useful distinction here, as I looked at the questions and comments, was between technical comparisons and outcome comparisons. We are moving back and forth between different designs of equipment and what they will or will not do, but we also have outcome comparisons which keep cropping up. The main thing here is that it seemed to me when you bring a group like this together because we were given such a tremendous introduction to the range of complexity, it isn't at all clear that we share the kind of information we ought to be sharing as a community with a common concern. All of us, all of you, let me put it that way, share certain things in depth and have had certain experiences in depth and as soon as you begin this business of contributing experience and examples of projects, we begin to discover a terrain. One of those features is that we may have an information retrieval and storage problem of our own as a budding community. I don't know where else society will get its leadership if it doesn't come from groups like this.

Then we got in par excellence to another set of questions which I simply called "Cost accounting and comparison." We had the cost of optional computer equipment, the cost of present alternatives and Bob Hayes' (I don't suppose he shocked me, but I didn't think I needed to learn it all over again) comment that we don't know the cost of present alternatives, such as libraries. It seems to me the conference par excellent raised a question which I think hit the number of areas of concern to us, namely, will the usual cost-benefit way of going about assessment any longer hold up? I rather think that we're in need of inventing, perhaps, some new formulations because we're combining hard and soft variables and also because we're talking about hardware and software in the same behavioral context. Lurking in the background is the business of fixed capital versus need, future needs and reformulations of problems. Universities are fixed capital and so are early investments by computer manufacturers.

There is a fourth question which came out of a set of exchanges involving Ralph Gerard and Licklider and several others. I thought it might not be a bad thing to remind ourselves that the boundary of what is far out may be something more than just a trivial concern. We did a little joking about it, and we said how quickly we could get "off" into DNA and some other things, but it seems to me that here again we came back to the question of whether this technology is doing old things better and more cheaply or whether it's going to do new things and give us a foundation for discovering even newer things to do. And here we have, I think, a very nice juxtaposition of what I call the incrementalists and the leapers. All one can hope is that they keep on communicating and stay friends, because it seems to me perfectly clear that when you talk about these alternative strategies and cost accounting (the Bob Hayes as a dreamer and an operator, and that's a combination you don't hardly get anymore) the only way to continue that was to have incrementalists and leapers in the same dialogue.

Finally, we had some points about languages, and even here, you know, one could see beneath the technical discussion of old, new and mixed languages the question of the relationship between the purposes for which we might view this complex technology and alternative language forms. It seemed to me that some of the questions went to syntax, to questions of behavioral context of meaning as much as they went to the question of the relationship between "give me a ham sandwich" and how do I address the computer first thing in the morning?

SAUNDERS: Thank you very much, Dick. I think we'll all agree that you've done a beautiful job of pulling together the morning session. I admire you. Are there any brief comments to be added?

BARKER: I don't have any comment, as such, with respect to the morning session other than to say that, for those of you who are not already aware of it, the National Science Foundation, in particular the Office of Science Information Service, eagerly awaits proposals in almost any one of those categories. With respect to the refunding of research, prototype services, and they're usually looking for people with ideas -- I'm sure that many of you around the table here, if you could carry yourselves away from your present research interest and would move into the areas that Bob led the discussion on this morning would be welcomed with open arms.

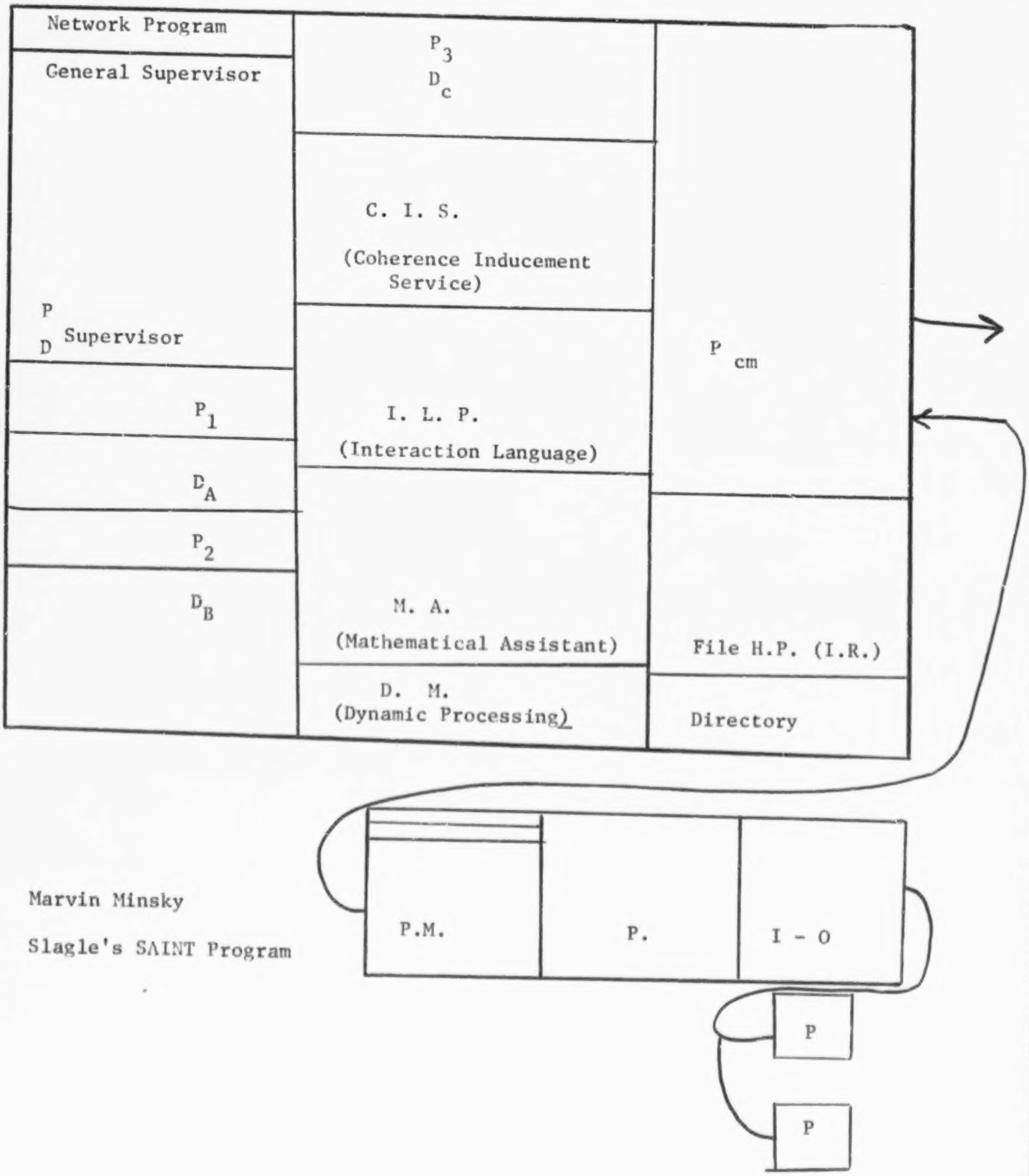
SAUNDERS: Now this afternoon we must refocus again on the Tuesday presentation where we were alternately multiplexing between some of the subsystems of computer-aided instruction and then the larger overall system of instruction. I assume here that the real system we're aiming at is instruction and that we have some very sophisticated subsystems to be sure, that pertain to the gross problem of instruction and also include in that total learning as well. Tuesday's presentations concerned, then, the courses, the course materials, and the resources of this particular subsystem. A portion of the total system is the storage media and how these storage media may best be used. We talked very briefly yesterday about that but didn't include all of the topics in this area. Now we focus on the questions of the storage media and retrieval, with particular reference to what might be called non-computer media, such as audio visual, video tape, films, and other microforms of storage mechanisms. To focus our attention on that is a man whom all of you know well. I would simply remind you that Joe Licklider was educated at Washington University and Rochester University. He spent three years at Harvard, eight years at M.I.T., five at Bolt, Beranek and Newman, and two at ARPA. Since 1964 he has been with

IBM as a consultant to the Director of Research. So at this junction I'll call on Joe Licklider.

LICKLIDER: Since Bob Hayes made such a brilliant talk this morning and since the discussion was so good, I'll confide in you that prior to his giving his talk, we exchanged papers and he didn't return mine. He's given it already. So now I'm going to do my best to give his. Another way to handle this, if it were already inside the computer memory, would simply be to swap the labels.

It seems we want to be concerned with things that don't depend on computer memories, but I hope also on things that do. We want to be concerned this afternoon with a fair spectrum of university activities. I think it's fair to say that this afternoon is supposed to be in concept in between the concentrations of the first day on CAI and the broadening of the spectrum that came this morning. So the spectrum won't be quite as broad now as it was this morning. But still, let's be concerned with teaching and learning, and with study, invention, research, conferring, administering, writing, decision-making, problem-solving, reading, translation, calculation, information retrieval, modeling, deduction, indiction, design formulation and so forth. We can't talk about them all individually but we can make a kind of a focus of conceptual attention. Let's think of the word "student" as referring to the role and (including the professor when the professor is studying); the teacher as the role, and we might include even teaching assistant, too, and add librarian, laboratory instructors and peers of the student.

ABSTRACT SPACE = MEMORY



Marvin Minsky

Slagle's SAINT Program

What I want to do here is to consider some of the materials worked with, let's say, textbooks, workbooks, notes and reference books of the encyclopedia type. I shall use the word almanac to refer to compendiums of fact that aren't wholly numerical and tables for compendiums of fact that are mainly numerical. Library books means books of the institutional library; books, journals, monographs, and laboratory equipment. In the old university, before the computer, we had a kind of studying that I'll call "ad hoc selection." These are the working papers of the student when he's working on a particular problem, maybe a couple of books and some reprints and so on. So we can think of a kind of interaction between the student and this kind of ad hoc collection and perhaps some of the student's peers if he happens to be studying in the dorm room. We can think of another kind of interaction among the students, the teacher, textbooks, workbooks, notes, perhaps also items from that ad hoc collection.

Another kind of interaction that involves the student is reference books, usually in the lobby of the library, usually not with the teacher, but sometimes with the librarian to help. We might work the teaching assistant into some of this. Still another kind of interaction of the student with the compendium of fact is the almanac and tables. Still another one involves the student, the librarian, and library books, monographs, journals. Still another one involves the student, the lab instructor, the laboratory equipment, and nature as reached through the laboratory equipment. Another, the student and his peers with very little reference to books at all. I mean to indicate by this a spectrum of intellectual interactions and to allege that only this one is truly focal in much of the discussion we have had thus far about computer-assisted instruction: the interaction between the student and the teacher with something like a textbook or a workbook. Now I don't remember what fraction of what I know, which perhaps isn't much, I learned from that mode. But somehow I doubt that that is so crucially important that it ought to assume the spotlight exclusively from all these others. So the first point I want to underscore is that the computer has a role to play, or at least there is room for the playing of a role in each of those kinds of interaction and since I've tried to indicate something of a spectrum, you can fill in with intermediate kinds; extend, extrapolate on both ends with others. It seems to me to be a broad field and, indeed, there ought to be other acronyms to C.A.I.

Let's focus for a little while on the computer as a partner in that sort of enterprises, and since this is a meeting on CAI, we'll give it a little bit more attention than the others. The second word here is library: CAI, Library, and Stored Information. I want to interpret here in these first few minutes library as having to do mainly with the library of instructional program and stored information. I'll broaden that in a little bit, but for these first few minutes I want to focus your attention a little bit on the view of the computer, that I think users (as distinguished from programmers) in universities are beginning to adopt, that MIT, perhaps I should say,has adopted for some time. This is a view that says the computer is mainly an abstract memory space, or an abstract storage space, and when we think about it we think about that space; we recognize implicitly that what is in that space can have a spotlight thrown upon it. Whatever has the spotlight thrown upon it leaps into action, comes to life as it were, runs, and the programs there are executed. So, that abstract space we might think of as just a single column, but I'll divide it up because I want to get it more up in view.

When you start out in a thing like field-wide computer assisted instruction, you're very likely to try to make a program to teach you something. When you do that, you can think of locating it someplace in the memory of the computer. Think of these as a succession of registers, if you will, with just so much space being filled up with symbolic material. If you do this without any interaction with the world of computer programmers at all, it's possible that this will turn out to be a homogeneous thing in which you can hardly tell which are instructions and which are data; which are operators and which are operated upon. Indeed, one even working with an author language is likely to string little bits of English prose together with operations to be performed in deciding whether what the student writes matches what the instructor said he ought to write. Make it a long session about a long course of fairly homogeneous material. After interacting with computer programmers, one would probably do the same thing in a different way, and separate programs or instructions (I'll say programs) from data. And perhaps with enough contact with programmers one comes to believe that that's a very fundamental subdivision, and there are just two kinds of things. There are the things that have to do with the operations performed, and there are these others which are by and large the same types; as if it were the verbs and the nouns of a language. Then one proceeds to do more programs than just this one; let's suppose, here is another and here is another, and each of those is divided into programs and data which would make subscripts; let's say P_1 and D_A, P_2 and D_C, P_3 and D_C. From there it will turn up that there are operations performed in these three programs which are essentially alike and they be performed upon different data. There will also be data, if only comments like that they were very well done, that appear in all three. And so it turns out that some economy can be achieved if we placed over here for common programs and common data, took out parts of this and put them over there and simply referred to them when the time came. By the time we have three computer-aided instruction programs, we see that not only subordinant parts to the three have some commonness about them but there is a general kind of operation going on that really requires a secretary or an executive or a monitor or something to handle the whole business of checking out and calling for this, that and the other. So we might call this the supervisor, and the supervisor will pull out still more parts of the programs and perhaps send them to data (the supervisor will also be divided essentially into programmed data). But then thinking back to what was on the board before, we will see that we really have the variety of applications here and these are only the ones that deal with study and teaching and learning in the university situation. Now there are others that deal with other problems so we really want to have lots of other programs also, each perhaps following along this model somehow, having a supervisor, having individual programs, having instructional and data parts separated, and so forth. So we might represent other sets of things such as I have drawn here for computer-assisted instruction, in which case it kind of leaps immediately to mind that one is going to have to have some kind of a general supervisor for handling this capability. Here I think of some research programs and some administrative programs and so on. Of course this installation which is, let's say at U.C. Urvine, finds itself to be part of a network of computer systems which may want to talk to each other until there is need for some kind of a network program up here, which won't be a supervisor because it will presumably be on equal terms with other programs in other places. I'll just have to call it the network program for right now; to start with a small set of computer-assisted instructor programs, and then work up the scale to indicate that these are at least conceptually imbedded in more complex terms.

This program can, of course, refer to the data-associated letter, Program I with data added. And, if we assume that it knows how all this was layed out in memory, it can come borrow parts of the program. This situation is not quite that simple. There is a whole community of people at work here and these things move around in this abstract space that I've been calling a memory. They move around for other reasons also because the whole enterprise grows and changes, but it's enough to say that they move about. All the supervisors have to have access to ten times the general directory.

Having this general directory is a very important thing. It makes it possible to refer to programs and to data by name, but it introduces complications. Computer programmers used to achieve this very important function of the directory with the aid of a compiler or an assembler that translated the code into the language that would run in a computer. At the same time this took care of memory allocations and converting names into addresses. Long before we get to the level of operation in which quite a few systems of programs are all supposed to run in a computer system at the same time it's just prohibitive to think of compiling everything each time we want to run because there are now going to be millions of instructions, millions of data in this so vast enterprize. Incidentally, I suppose the computer-assisted instruction contributed rapidly to the great growth of the self-motivation of doing computer operating. This directory has to be something that can be consulted at the time the programs are run and not at the time they are compiled.

Here we have a kind of on-line index to the content, which can be approached with the name of something, or perhaps a complex name referring to some biological arrangement of data and bring forth what is wanted. So the directory isn't just a table, but is a file or pin-point program or information retrieval program. We come to a place where information storage and retrieval within this system is a subordinate function that must not be handled by the person who writes his computer-assisted instruction program or even by a supervisor unless all the computer-assisted instruction is partitioned from the rest of the world, and you give up the idea that we will break through into the library from this passage. This thing down here is a service within the system. How to use the files? We tend to think about this thing as just an abstract memory but of course that's not always right. The user is sitting at a console of some kind, though I remember when Ed Frenchkins first launched the idea.that information processing is something that comes through a wall plug and you don't anymore think about where the computer is. You don't even care, so long as the function is fulfilled. As long as it works you tend to forget about the physical source and consider only the wall plug. But the console, which is with you, is the thing that takes over the prestige characteristics and the physical presence of the computer. The interaction facilities and the interaction language and things which you as the user think about as well as this mass of memory says there are someplace in this memory arrangement, arrangements that we'll call the interaction language. That also is divided into parts, programs and data. But to the user that is a function, a service. Down here are more of these packages to talk about besides information retrieval, display, and control. I won't take time to enumerate all of them but certainly there is mathematical assistance. After all, computers started off as things to solve mathematical problems and it would be a shame to prohibit them that initial function in the process of going on to new worlds to conquer. I think that in some circles that mathematical assistance has gotten quite sophisticated. It is that there is more to the program of data or computer-assisted instruction than meets the eye when you first write an individual program. It gets complicated because you're trying to do something that is part of a community; that is part of a large on-going enterprise. But that's not so much a hindrance or handicap as it is a facilitation, if, indeed, you can use already created and operating resources such as the file handling, the mathematical assistance, the display, and the interaction language.

Now this has all been quite abstract without reference to any particular physical memory. Although I have drawn this small it can indeed be a very, very large thing. One can think in terms of millions of registers of information, and indeed when one is talking about kinds of stores we were discussing this morning that are not directly processable by the instructions in the computer's processor, one can even think of affording such memories. The memories that the computer can process directly are getting much larger these last few years. It used to be that a million-word memory was a great dream. I used to get awfully tired of hearing Minsky and McCarthy say that all we really need is a million-word memory. Well now at least one can be delivered. Even so, compared with billions or tens of billions, this is small. And so there is this unhappy fact of life that says that information has to get transferred from one apparatus to another in order to get it into connection with the computer processor. This is the primary or processable memory. There is an input-output arrangement here which communicates with the console, that's roughly the paradigm. Now in the present technology this of course is a core memory and this one may be a round or a disc or something made of data cells or in the coming years perhaps made out of film clips. In fact, this is probably a heirarchy made out of those and other technological devices. But since part of this general supervisor and part of this network program preside over here and can go get the other parts of themselves wherever they are needed, one need not think about all the differences. In the coming generation of computers designed for purposes like this the location of bits and pieces in this big memory are handled in the physical memory that really corresponds to this abstract one, partly by programs and partly by hardware in such a way that the user, or even the programmer, need not think about it. That comes back again to underscore that one may think in terms of an abstract memory and forget the details.

Now let's focus for a bit on the languages in which things are written. In many places I suspect the work on computer-assisted instruction will be carried out mainly in a single-author language. In that case, this author language now is going to be implemented in a way that is a little like a compiler, except that it will operate while the programs are running and will interpret as well as compile. For that reason it will be possible, in the single language instances, for the supervisor to be built into the implementation of the single language. Now that's fine as long as you are trying to run a very tight ship and the forces that lead to diversity do not impinge upon you too hard. I would point to Alan J. Perlis at Carnegie Institute of Technology as a man who for some time ran a whole computer center with a focus on a single language. He did so very successfully and the great advantages insofar as coherence of the product were clearly evident there. Almost everybody's programs were in ALGO and the technical problems of calling sequence and soforth were pretty well handled. In Alan Perlis' very tightly-run ship, commanded by a commander with an iron will, the diversity of languages was irresistible. I suspect in this area it will be too. I think it will not be possible in many or most instances to force things into such a mold, in which case the facilities will have to become more general and yet pressed up a step into this general supervisor. This is essentially for time-sharing systems as this must be the time-sharing supervisor.

This problem of getting the several services I mentioned to function together in a coherent, integrated way is a very difficult problem. It's just in the process of being solved. There are many ways to handle it so different places will try different ways almost surely and in some places, different ways will be working side by side. Unless you want direct instructional programs, we'll have to make a choice: whether to get used to this complex organization at an early date or whether to withdraw into the relative simplicity of a single-purpose dedicated system, where some of this (which looks like nonsense to the individual user who is focused on his own particular problem) will not get in his way. But as he does this he must realize that he is just putting off the day when he will have to adjust to a complex environment and most of what he writes will turn out not to work in a complex environment; that he is buying temporary advantage at the sacrifice of long-term achievement.

My personal philosophy about all this is that the difficult problem and also the important one is the achievement of coherence within the community of people who use computers in a university environment, (I would even go farther and say among universities that can communicate with one another). So I think it is better to work within such a concept and to adjust to the problems; to recognize them as they arise and try to help solve them. But I shouldn't inflict them on others. I'll point to one small advantage. As soon as one works in such an environment he starts to write his programs in terms of something called "pure procedures." This has great advantage in that the same program can be operating for several different people at once. This is an advantage wherever there is commonality in the use of programs. It is interesting to note that that is exactly a reversal of John Von Neuman's great insight that computer programs can be treated as though they were data and processed during the execution of programs. Exactly you should never change anything about a program while it is running for fear someone will come along, use the same part of it and it will be in the wrong state when he uses it.

A program now is envisioned in this context. It is absolutely not a monolithic thing. It has structure of a kind shown, which is to say it makes frequent use of facilities that it can find through the supervisor. Some of these are generally used subroutines or subprograms. Others are functions that the supervisor himself fulfills in a mysterious way, through commands to the supervisor. I want to emphasize that these things have to be linked at the time they are executed and I want to combine that with the requirement that they be called by name, either subprograms or data, and point out that the linking of things together at the time they are run without the use of any knowledge about where they are located except what can be picked up through the use of some kind of a directory is an interesting technical problem that is just now in the process of being solved. Probably that is enough to disconcert you. The aim of putting this on the board and going through this discussion was, I must say in part, to disconcert you. I wanted the opportunity and I took it to say that this is a complex context into which computer-assisted instruction ought to fit.

I talked only about the technical context; I didn't talk about the social one, and I want to mention it even though I don't have time to elaborate upon it.

The implication here is that other people are doing things that are related to what you are doing -- you as a writer, an author of computer-assisted instructional programs, or even as a user of them. So you must have some interaction with these people and some of that will just be the ordinary telephone or face-to-face in the corridor kind of interaction. But some of it should be through the system, and that implies there should be another service that I didn't talk about before. I shall simply call this the "Coherence Inducing Service." Now what does it do? Well, it handles documentation of programs, that is, it requires of you (when you do the programming, which presumably you are doing at the console through the system) explanations of what your objectives are and explanations of how the various subprograms you produce meet those objectives. It may even involve a descriptorization or some other information-retrieval approach to the labeling, indexing and retrieval of programs, and of course, it has an expert consultant service. Indeed, when you are working through a system of this sort you can get connected to other people and that's really essential to my whole point: that this is a social phenomenon more than a technical one. It's almost a social movement and it's absolutely necessary to get together in teams through the system to get anything done that will not require redoing as soon as you see what the broader aspects are. There are all kinds of conventions about doing the little technical things. Just to call a subroutine is a little technical step that can be handled in a hundred different ways, of which probably thirty are about equally good for any particular purpose. Left to our own devices, as we tend to be in this area of effort, people will choose all thirty of those and nothing that anyone else has done will fit together with what the others have done. This general difficulty, this chaos, this effect that thrusts itself into such situations can be helped to some extent by deliberate organization. It can be helped to some extent by getting one system that's very good and that's polished and works early so that people will tend to follow that way of doing things and perhaps never think of some of the alternatives. But you have to have considerable diversity in order to get optimization within a thing like this, so you can't really handle it all that way. It leads also to an approach that is a programming system designed not to prepare programs initially, but to modify them. So I think an important part of such a system is the small group of programmers who find the programs that show great promise and translate them over into a consistent language so that the whole thing will work as a system.

Now, that's most of what I have to present. Let me go on to a slightly broader range of topics and hope I can get you to discuss these. A CAI program tends to be a course or a part of a course, a thing thought through by an individual or a small team, quite coherent, quite well integrated. And that, indeed, is one approach and it may be the best approach; it's certainly the prevalent one. A second approach says that the computer is very useful in some functions which come up once in awhile in almost every course of instruction. We saw some of that when we saw Atkinson using the computer as a device to facilitate Drill and Practice, a kind of an auxiliary to a course. I think there will be many of these things. Tony Oettinger at Harvard is much interested in one set which is the use of the computer with a display which is an aid to the teacher of a seminar in mathematics; a display that will make it clear to the students how complex equations and other mathematical formulae behave. You can vary parameters and watch the graphs change shape and so on. You can do all kinds of dynamic illustrations of the behavior of ideas. Note that these things require only form programming; they don't require content programming because the form is essentially the mathematical system of constraints that operates and then on-line in the class you put in the contents to see what the form does to it. Beyond those things we come to programs which are so generalized that they can be shaped up by data. Examples are arising in the field of syntax. They got there from computer programming languages, which determined that one can build a compiler that would compile one or another language, like FORTRAN or ALGO. All one did was to feed in a table of statements in a formal language that defined the syntax of the computer programming language.

The same thing is being done with natural languages. And, indeed, a couple of weeks ago I saw an instance in which a Russian syntax was pulled and a Hungarian substituted, and it did a nice little syntactic analysis of the sentence in Hungarian, which is a semantic demonstration but it obviously works. Note that here we have, instead of the simple programmed data, the programmed form at its highest level. Then we have data slipping in to define or specify the form______ in a particular natural language. In this case this will be Russian and not Hungarian or not English, and now more data coming in the sense of actual sentences in some natural language to be analyzed. This will develop itself, and I think we could probably find an example if we worked hard in which there are about four levels from the one that is clearest programmed and the one that's clearest data.

I want to go on to data banks, data bases. In fact I might call them information bases, because it's obvious now that they are going to contain computer programs as well as data. Results are fairly obvious but you never know really quite whether it is program or data in some instances. Data bases are commonly encountered in the Pentagon, in the Military General, and I think in other parts of the government. The Census Bureau, for instance, collects demographic data in huge quantities. These things are only starting to get into university life, but I think they will become extremely important in university life. By a data bank or an information base, in the most general form, I refer to computer programs, the data the computer programs operate on, useful statements of the kind made for example, in the HANDBOOK OF CHEMISTRY AND PHYSICS, things you'd find in an almanac, and so forth. I want to exclude from present consideration, although I won't say it doesn't fit under the title, statements in natural language, paragraphs, and so forth. I don't want to get all the way over to include all of the most difficult material that one finds in a library. So within this scope, what I would call amenable information, this isn't too hard to process by computer. I think there is going to be a tremendous effort and tremendous profit in the coming years. I would urge that our discussion include also consideration of what universities are going to do about such data. As soon as one starts to have truly voluminous resources of data at his disposal, he sees that little section called the "file handling" or the "information retrieval service" become extremely important. Most files are prestructured or hierarchical. For instance, you might have a geographical one that starts out by sections of the country, and then states, and then subdivisions of states, such as counties. You might want to do a border registration or something of this sort to try to predict the outcome of an election. If somebody then asks the question, "What is the ratio between the Democratic votes of Catholics in the middle bracket of income," or some other religious income or ethnic grouping. Here is a question that runs counter to the grain of the file because this question asks for a little sample out of every section, every state and so on. And that difference can turn into and time score the difference between getting an answer, in a big file, in a few seconds and getting an answer tomorrow afternoon. It's really just black and white. So there are all kinds of schemes about dynamic adaptation to the general line of inquiry. Files are continually being rehashed. The concept of an index that is bigger than the file, which was a shocker two or three years ago is now commonplace. Of course the index is going to be bigger than the file.

I think of these things as getting into the social sciences, political sciences, demography and so forth, even in a bigger way than they get into the natural sciences, and I think of a very sophisticated technique developing for the use of data of this sort in a particular problem. For example, such data are often fragmentary and the way one uses them is not to deduce from them by adding up columns and rows and so forth and calculating the results, but by defining models, operating the models against the data to see which model or which hypothesis best agrees with the data, then perhaps predicting what some other data that aren't available yet ought to be, and then going out and getting those. I think ways to use data bases will come in for a lot of attention.

Now I'll just mention question-answering systems. In order to get the concept of the question-answering system, one has to see the notion not simply of putting data into a data base, which can be gotten out and read, but of putting data (not just numeric but alpha-numeric data) into some formal structure that can be processed in a meaningful way by a computer. As an example of a formal structure I'll mention predicate calculus, because that has been demonstrated. It turns out that a good man can map over into predicate calculus many statements that are ordinarily made in natural language and when they are there, the computer, suitably programmed, can derive answers to questions. The demonstrations have been rudimentary so far but in principle quite convincing.

I said the data base doesn't need to contain just numbers. It can contain statements in a formal language such as predicate calculus. But it can also contain materials which are not analyzed in such a way as to be processed by the computer, particularly microforms, tapes, pictures of all sorts. And one comes to a parting of the ways, as it were, in what we touched on briefly this morning--computer processing of content versus mere computer fetching and making available of content without reference to what's really in there. Of course the index, the directory, all the apparatus of information storage and retrieval, the apparatus of so-called bibliographic control will be processable even in this latter case. Besides the scanning of microform and transmission of the scan signals to be reconstructed on an oscilloscope, there is a very interesting thing about transmitting the microform itself. Anybody who has ever seen an old-fashioned department store with a pneumatic tube has the concept but also has the basis for rejecting it out of hand because such a tube is very expensive; it runs slowly, it clatters and so forth. Another thing--coaxial cable. We'll certainly have that strung around our universities soon, if we don't already. They'll say "well , Harvard is putting $100,000 of its own money into this." Microform is very small. A strip of microform will fit inside a coaxial cable and you can deliver microform at very high rates, 20, 30, maybe 60 mph. So don't sell short transportation as a way of handling microform.

There's lots more in this picture, but I think it would be better for you to talk than for me to continue to talk. I hope I have said all the wrong things. I have tried to be a little disconcerting. But I think we are heading in a slightly wrong direction in some of this, and I've tried to paint a picture of another direction.

SAUNDERS: Thank you very much, Lick. I think I will ask now that you suggest topics for discussion.

GERARD: At the risk of opening Pandora's box again, I'm going to mention the brain because it leads to a concrete question about your main box there. A good many students of the brain had begun to have the idea that the connecting cells, the glial cells, the packing cells, in the brain were more important than the neurons, what we had always believed to be the critical functional neural cells, which have these long wire extensions from them, because in the largest and more intelligent brains, brains with much richer capacity, there was proportionately a much larger number of glia than the neurones. Many of us questioned that and some work that was done in various places, some of the best ever at the Mental Health Research Institute at Michigan, I think pretty conclusively show that the reason glia increased relative to neurones was because glial cells were necessary to help maintain these connecting fibers which were part of the neurone. They were sort of part of a metabolic nursing cells. So this in turn points out that as you get larger and larger brains and more and more neurones, the problem of connectivity becomes a tremendously crucial one and I can't help wonder in your very rich interrelations co-op system what the problem of connectivity is going to amount to, whether that may be the crucial limiting factor.

SELFRIDGE: Such a system as Lick describes seems to me to offer some of the only tangible hopes for finding out what the nature of real intellectual collaboration is. I'd like to hear you discuss what the technical requirements are for using such a system for people learning to work together.

TONGE: You spoke briefly of dedicated systems and perhaps their inappropriateness. It seems to me we can find examples of dedicated systems such as____________________ examples used to pure procedures very nicely. The other scheme is things like

Project MAC or 032 systems which put out at the terminal a large capacity to set up the machine in the machine language. Are you saying we have to go that far or to that in between place where there is strictly one language you can use? On the other hand, you don't have to make available to everyone and for everyone to become a programmer, a real professional efficient use of this thing.

RIESER: I would like to ask you to discuss that with which you began and mentioned this as a student. I'd be curious as to what kind of capability you have been expecting to assume to truly reap the benefits from such an existence.

MILLER: Two questions. One, to what extent does being on-line in this type of intellectual community restrict a student and a scholar in his own idiosyncratic way of coveted processing? Does it need to? The other one is, what sorts of rational support might be necessary in order to get pilot projects started in this area? I felt that in our discussion this morning some of the thinking was that we must put up with the hardware that we have now and software that we have now. If the university is to be the leader perhaps they have to ask the industry to supply the hardware. If it doesn't exist, then government agencies might supply funds to make possible some of these things. You and your associates have done some of this in the past. To what extent is that going to be necessary in the future?

GIVEN: The role of this system as used by the student has been mentioned; I think its use by the teacher is equally important.

COFFEE BREAK

SAUNDERS: The recorder for this session has been Lou Bright and in consultation with him we have reduced the questions by Lick and others to four broad topics you'll find listed on the blackboard: 1. Students and teachers: their capabilities and restrictions. I might also add that you might address yourself to the issue of realization. 2. Hierarchy: both machines and people. 3. The question of financial support both in the magnitude and sources. 4. The general subject of university data bank.

FLOOD: I have a question really. Computers are used for research, ________________and we've done very well on that. It's a little difficult at this stage to do that because it's very hard for me to separate the research activities in the university from the education activities. I'm just wondering to what extent we should___________on the computer research.

SAUNDERS: As chairman, I will rule that research and instruction are inseparably one! We are talking now about students and teachers; their capabilities and restrictions. This is a question raised in the discussion after Lick finished having to do with what can we expect of students? What can we expect of teachers? And I raised a corollary issue of whether our expectations are realizable.

EVANS: I'd like to make a comment related to Fred Tonge's question. I don't see any advantage really or understand Fred's question with respect to the dedicated system. I don't see any advantages to the user who prepare course material or the like who wants to work in the restricted framework in having a system with less capability and less generality than the system described. Such a system if well designed doesn't impose on him in the performance of restricted functions, and possibly the opportunities for growth, the opportunities to be able to not have to redo it as he becomes more sophisticated and so forth are very great indeed.

LICKLIDER: But Fred pointed out as he asked the question, that the fact is, the example I was using in the pure procedures was fine in the simple system and not in the complex one. And I think this is a very important point--that the complex systems are so demanding of the intellectual concentration and effort of the people who make them that although they see in their mind's eye many features that they are going to build in, they do not in one year or two actually accomplish those things. Whereas in the simple systems I was trying to make the point about the trade of local gain at the expense of long-term progress. In the simple ones_________________ you indeed find sophistications and productivity that you don't find in the big ones.

EVANS: That's true, although this is the work of the system's builders and need not for any extended period of time be of concern for the system's users. We are in a painful period at the very moment, I don't deny that. But this is not a matter of years' duration in my opinion.

LICKLIDER: Well, it already is.

EVANS: There will always be new developments of course.

TONGE: One of my concerns is I wouldn't feel uncomfortable if what we're trying to do on Project MAC or SDC or something like that or SDS-940 system at Berkeley to do computer-assisted instruction in the sense that I think I could make use of many of the tools and provisions that are there. I'm not sure that it would be a very comfortable experience now or next year or the following year for a number of the people who are trying to use the computer as an operating instructional tool and I think a Course-Writer system limitations that both Lee and I are happy with turns out to be a fairly comfortable tool. Somehow it makes me uncomfortable when someone who has been using computers for a while answers, "Well, it's really no limitation to have all this freedom. In particular_____________ all this freedom may answer the question of an immediate language for writing courses. It usually postpones for a long time all the supporting things we talked about yesterday for the specific user. Handling student records, bookkeeping, making it easier for the author to prepare things, playback, and so on. I'd be glad to have further comments on that. SELFRIDGE. What I mean is from the slight experience I've had with the course right here, I would think you could implement that in Project MAC in one week. Similar programs have in fact been of such complexity. In regard to Project MAC, you don't know what you get until you come and try. Then you realize the complexity.

EVANS: This is the nature of my comment. I don't see why if one wants to live within the framework of Course-Writer, you can't be a resident at one of these systems and try it out. I see no reason why such a thing cannot produce procedures and data files and so forth which can be operated on by other systems.

TONGE: But on the other hand, it seems to me there is a gap between that and making available machine language from the terminal.

EVANS: I don't think you have to make the machine language available from the terminal for a particular set of users just because the system has the capability of doing it. I think what we proved is that you can build a sophisticated system, you can have essentially all the characteristics which were described, it doesn't have to cost a lot of money, it doesn't have to take a lot of time to develop it. What we have learned is probably sufficient to get us by those hurdles. I think we can argue that the system we built has certain specific characteristics and certain improvements. The facts are that the machine has been redesigned and the system has been implemented and that we have gotten to a high state of development within a year, and it is now being marketed. There is enough known about this particular thing now that certain things can be done by people who are not necessarily researchers.

LICKLIDER: It seems to me this discussion should tie directly back into one in the following way: This hinges critically upon whether Dave Evans is correct in thinking that the universities who have been developing time-sharing interactive computing systems are almost finished, or whether, as I see it, they are just beginning on very long tasks.

EVANS: Excuse me. I don't think that it's finished, but I think it's kind of a first plateau in which the systems are useful at this level of sophistication. Its use of alternatives are well enough developed that it doesn't require each user to be a researcher and an assistant himself.

LICKLIDER: All right. The point is that if the question were about anybody else but students and teachers in universities I would argue that the intricacies of the system are the worry and responsibility of system programmers and it can all look fairly simple to the user so that no great skills, no great understanding of the intricacies will be required of the user. But, since they are students and teachers in universities and since, as I see it, universities are embarked upon a difficult and important task that is going to take ten years or perhaps more to develop a new way of dealing with intellectual problems with the aid of computers. The students and teachers had better learn the thing in much greater detail. It will place big demands upon them, but they will be very interesting intellectual stimulating things.

STARKWEATHER: I am in a position of having a teletype on order for more than six months, waiting to get on to tape system. I think I will appreciate the fact that not only will there be some author-oriented or user-oriented systems that I might work with, but that there is also involved an assembly language level available that will allow me to adapt some ideas I might have outside of such systems if I want to work at it that hard. I think if I were to adapt an author language to that system I could very well arrange it so that terminal could operate with a user who is completely unsophisticated about the system, and it seems to me that this is a perfectly reasonable notion, that a system builder can even, from the same terminal, build allocations to the system which then can turn the same terminal over to another user to operate on a different abstract level.

RIESER: Lick, you put teachers and students at universities in a separate category and you expect greater sophistication of them by far. You began with a very nice table and you discussed some of the interactions, all of which are a combination of long education both by the students and teachers. However, many teachers are students and many students will become teachers. The basic mode I think is reading and writing. In the past a student has gone to lectures, deplored by many, but he brings something from them, so he picks up enough notes to know what to read in books and finally turn in papers which another one of your categories, "teaching assistants" often read and got back to him. I'm trying to get a sense of the gain we are going to make from this. It is going to be quite a change from the past. In particular, this whole question of the subjective essay response that a student makes in a long paper to a teacher for example, brings out his ideas creatively into a package. I can't yet quite place where the computer will stick with him and where they separate in there.

LICKLIDER: Will he write this essay in a formal language or will he write it in an open one?

RIESER: I don't know. I think that in what you project our mode of interaction is going to be very different. It's going to be quite a shock when that student walks into the university.

LICKLIDER: I notice that at Phillip's Academy at Andover, Mass. the teachers were quite excited because this fall they were going on-line with the console.

SAUNDERS: I'll interject here. I suspect that the answer to this question is that the students will use a very informal language ~~and~~ will be misspelled.

STARKWEATHER: Most of us feel the need now and then to write these papers too. That is, it's not just a burden placed upon students to communicate via the writing of a paper, hopefully created. I have a number of colleagues who find this the most painful part of their professional career. It occurred to me some time or other that it might be possible to write an interactive program to help them with this chore and maybe we could try to do the same for students. It could sort of hold your hand and take you through some kind of logical procedure which an editor might usually do to help you write a paper. It just might get the steps down to size where you wouldn't be so filled with anxiety with the whole effect, and you might be able to get to work on it.

LICKLIDER: Bob Hayes says that the amount of literature developed in the next ten years would equalize the fact. He'll have to bring that down to the next two years of something when we start assisting the people in writing paper!

STARKWEATHER: In some instances of course the computer may talk you out of it.

MILLER: Lick hasn't yet said what are the constraints of individuality and idiosyncrasies in operating a system of this type.

LICKLIDER: I think you know that I think there aren't any. I think it opens up broader horizons to creativity, to initiative and innovation.

MILLER: In any human community I've ever heard of there are constraints just being in it. There must be some form of conformity or similarity required. Isn't that of the essence of community?

LICKLIDER: If one is programming, an influence is to program in a frequently used language because it takes too long to get at the little used one that is off in some distant store, but that doesn't inhibit diversity apparently.

MILLER: Why can't a hypothesis apply to these special languages? The notion that somehow the language determines the form of cognition which is carried out in that language?

LICKLIDER: Yes, but depending on what kind of cognition you want to have, you select the language for the purpose, which is where the flexibility comes from. At Carnegie Tech, several languages now have forced their way into use, all understand the same storage allocations of data, so one can write out a few statements in ALGO, a few in FORTRAN, and a few in LISP, referring to the same data, and the compiler happily connects the things up so the program runs. So essentially you can use the language that's best to express the kinds of thoughts you are trying to express.

KOPSTEIN: I want to raise a point that I think is related here. Presumably in this system it would be possible not only to deposit your fully-baked but also your half-baked ideas and to use the system in fact to give it a little more right state. Now the question is, within that would you leave them so that other people can access what may be partial but potentially useful information, or would you perfect them? At what point do you usually take them out or augment them?

LICKLIDER: I think I'd make things available to the point at which I started to get insulted for leaving them exposed to public scrutiny. If they're bad enough I'd better not leave them out there. If they have a value then I should take advantage of it even though they aren't quite finished.

DAVIES: I think we should distinguish two classes of CAI. I think most of the attention, especially yesterday, was given to the highly structured approach which seems to be very appropriate for elementary reading, arithmetic, and undoubtedly a large range of other things. But I think there is another category which might be applicable to less structured things like teaching social sciences. I would like to see more discussion of this. For instance, maybe what you want to do is provide certain kinds of open-ended computer facilities and language capabilities that are used by a class of students in conjunction with an instructor. Let's say you were teaching a course in economics. If we had machines and languages that would permit us to divide hypotheses and set up models and perform experiments and test the hypotheses and do all sorts of things on the computer, then you don't have to write this detailed card telling exactly what's going to be done. You just provide a facility and you rely upon the instructor to figure out how to use this facility to make a good course. This side of things hasn't been discussed very much, and I think that it is of very great importance and brings the instructor back into the picture too.

FLOOD: I want to make one comment about this last-minute change and then make a remark I've been wanting to make separately. One of the things that impressed me about the MAC System that I think may be true in other systems and that would be apropos to Dr. Miller's question about the effects on individuality, is the following.

Someone using the system thinks he has a pretty good idea, and he uses it for awhile, perhaps a program he has written or a data base or a combination. And he gets enamored of it after awhile and he tells a few friends. They can exercise it in his file. If he gets really proud of it, it might get favorable attention, and so he publishes it in preprint form. Say this one is called a "C-Test 7 model", all users get this message, and when you get your console each morning or evening, you can find out how it works by asking him. When he gets a little more proud he may write up a ditto of one or two pages to tell you enough about it so you can really try to use it. Then it catches on. Now say there's an old competitor that has a command name like EDIT. He notices that people keep asking him for his and they don't use the old one. But in the management of MAC, it looks these things over, and if it looks like time to make C Test, the new EDIT program, then they make EDIT a C Test. Then there are a lot of reactionaries that won't quit using these things, and you keep it around for awhile. After awhile it sort of dies out. Now I believe this is characteristic of the very important cultural feature. I'm sure there are other examples like this which are cultural, they have rewards mentally, they are motivated. In fact, I think this is a very important aspect.

MILLER: This is cultural evolution, natural selection process, very much like the well-known Gerard, Kluckhohn, Rapoport article in Behavioral Science on how new cultural inventions are selected in or out of the society. This is an excellent example of that sort of thing.

FLOOD: I've been trying to find an opening to make this remark, but it never fits anywhere. So I'll make it now. The thing that has bothered me is that although there is an emphasis here on what Lick described, using a computer to do a tutoring session on the students at the Console and so forth, I think when somebody says computer-aided instruction or computer-aided teaching, there are vastly more important ways that the computer will be important, for example, in undergraduate and graduate work in universities even in the rather near future. I'm not at all sure whether this is at all true in any good sense in the secondary level and elementary schools, but at least in the undergraduate program, in the graduate program, in the post-doctoral program, and even in continuing education. I think that many things are far more important in the near future, perhaps in the distant future, and yet we aren't discussing them here.

I don't have any convincing examples even to myself, but let me mention two things to try to identify my concern. Some of you may remember that the first day I said I felt a little bit radical and I mentioned the highways, the surrey with the fringe on top and the one-cylinder motor. They were all very exciting without any roads or all of the other things that go with our modern society. The use of automobile transportation is pretty hard to see from that time to now what society is going to be like, how society goes, is a lesson we learned in the case of automobiles and other vehicular transportation, and I think we could here. Now Licklider often refers to us as the "on-line intellectual community". I think that's really a very fundamental thing. Let me take the C Test thing I mentioned earlier. A very bright doctoral student in electrical engineering had to type his dissertation at MIT, and he didn't have any money. There were all these fine typewriters sitting around. They were all nice selectric typewriters, and they were just hooked to a computer. So in effect he wrote the C-Test 7 program, which is a context editor in order that he could write his dissertation effectively. Then everybody began using it because it's obviously the best way to manage an endless file any time. I think that is a very important educational contribution done by a doctoral student out of necessity.

There are many things of this sort that build this on-line community, including programs that will allow you to design a reactor. I think Licklider stressed that, but I didn't feel it was stressed enough. I think that's what we should point to primarily, but build the roads, the stores, the community mind, and work toward that end through local emphasis or intercampus communications, and so forth, while we are also doing many things such as the tutorial program.

GERARD: What I have to say came in very properly just before Merrill's remark, and at the end of his remark I'm glad to say it fits in there properly also. I have been thinking along the lines that Jim Miller mentioned a moment ago. This problem of freezing and using or continuing to keep flexible and developing is the universal problem of evolution, not merely social evolution but biological evolution. Nearly all the species that dominated the world at any one time did so by adapting specifically to the environment in which they found themselves. When the environment changed a little bit they went out by some more generalized and less successful species than could make the change into the needs of the next environment, they took over. When a man is going to prove an exception to that because he can control his environment remains to be seen. The particular application of that, it seems to me, we were talking of various stages in development of this new resource. (I hesitate to call merely a technology), and as Lick said, at the university level one has to really master the thing. It must remain part of armamentarium so that you full understand it and can improve it.

What about the use of frozen models at various times at the lower school levels where the demands are not so extensive and where the consequences of introducing them are enormous and are horribly overdue? I want to ask a specific question in this connection, coming back to the exercising of the brain that we got into this morning. There is no possible doubt that one could greatly enhance the capacity of social functioning of most human beings by giving them very early in life the kinds of experiences in using their brains in these ways that enable you to make yourself an athlete.by appropriate muscular exercises that have to be done early in life. The primitive abilities to use symbols and manipulate ideas and so on have to be gotten early just as the ability to get pattern vision has to be established by early experience. This kind of intellectual exercising, in my impression, goes on in lower schools to a very negligible amount. We were told the other day that there was only ten percent effective contact of teaching at all and most of the teachers at that level are occupied with the drilling of factual material, and many of them, of course, don't do that very well. It seems to me that one of the tremendously important possibilities for turning civilization around this technological unemployment corner is to start very soon now in using these resources at the lower level. My question is, do those of you who are masters of the current state feel these techniques can be effectively utilized now or in the very near future? I'm going to tack a tail to that question because Lick mentioned at the end of his talk that he had overlooked the inclusion of audio-visual resources, so maybe in answering that we can also discuss this aspect.

LICKLIDER: In addressing that question you disqualified me at one point. I think it is absolutely right to attack the problem of computer resistance to education at the elementary and secondary level, to use systems that are simple enough to be conquered and mastered. I'm not advocating that nothing can happen until the kind of system I drew on the board can be made available to every school district. It seems to me that the fundamental problem is two-fold. There is cost and there is actual value of the education provided. I have no question that the actual value of the computer resistance is ____________________________. I think that we are in a struggle right now to get the costs down to where the thing can be afforded by the school board and by the nation. I would argue that in uses of computers in universities, by the time you consider all the universities and colleges in the country you may have approximately the same problem of where can it possibly be financed. But the situation is fundamentally different because systems of this kind are greatly needed by national information systems, by the Military, by industry, and they are so complex and difficult enough to develop that it's almost certain the universities will be called upon to do the job. So these can be financed, at least to some extent, as research and development enterprises, and they don't have to be thoroughly affordable before they are launched on a big scale. Does that help at all?

This isn't the time for network talk, that's tomorrow. It seems to me that there is a real resonance between the requirements of educational TV and the requirements of computer signal, when it comes to distributing them among the universities and other places that can use them.

ATKINSON: I was talking at noon with Dave Evans about how he viewed developments over the next ten years in the role of time-sharing, and he gave me quite a different view on what systems like this might look like. I posed the question to him that if I really wanted to cover the Bay area with terminals, not of the complex type but which would carry tutorial type activity up through the lower grades. Dave took the view of what the system would look like. Would you like to talk about that, Dave?

EVANS: All I can is remember saying yes or no to your question! We tried in our conversation at noon to distinguish between time-sharing machinery, particularly centralized machinery, because there is some logical need for them, and because there is cooperative action, with common data bases and so forth. And the reason that has been more commonly given is that the only way you can afford to have a hundred people computing is to have them use the same machine so that their peak demand is not smaller than the sum of the peak demands of the individual. My feeling is the one I expressed earlier, that the reason that we don't now justify these shared-central facilities is that the need for centralized facilities for cooperative purposes is much more fundamental than the need to share for economic purposes. I simply repeat what I said this morning, that we can afford in the not-distant future to have very great logical capabilities assigned to each individual person. We can expect quite a different sort of economically practical system when this is fact than we can now when the only possible way to get computational capability to an individual at any reqsonable price is to have him sharing a large central console. The central information system, storage and retrieval, is important here rather than the central computational abilities.

LICKLIDER: I'd like to agree wholeheartedly with Evans, and say that even if the time comes, as it well may, that every console can have the processer associated directly with it, if you have a thousand users or a thousand processers, you still want to have the common memory.

EVANS: May I make another comment? I think the implication here is for those who are doing research in the area who can get the money (some of this research has to be wide-open when we put ridiculously expensive consoles in the locations because you know that you will be able to afford set logical capability later). I'd also like to comment in respect to Jim Miller. We do have some conformity requirements currently that we don't like particularly well and that are not fundamental. I suspect the most difficult one is that we only know how to handle a very small number of different kinds of data structures at the present time. But I think these really are fundamentally limiting and it really requires conformity with these things within the present system. I think if we knew what other kinds of data structures were useful, what other kinds of data structures people really use in their cognitive processes and so forth, we might be able to relax those constraints, but they really are constraints of the present systems. Also I think from a practical point of view we really are constrained quite often currently to a symbol. Of course that's a much shorter-range constraint, but it is a constraint when you sit down to a teletype machine, which is what you do. I really think you have to know something quite fundamental about the structuring of data before we can really say we don't have this constraint being placed on the community conformity requirement on the user.

BLAKESLEY: The challenge for higher education seems to be the training of teachers so that they may eventually use these tools.

BRIGHT: We differ in some of our philosophies when you start talking about application to students where the programs are very well developed. Here your philosophy is that the only way that you can get the cost down is to get approximately 100 consoles in a school all tied in with a computer on that particular site. I disagree very much with the idea that the central data thing, in that the whole thing hinges on the audio. You're not going to put your audio into central bank if each one of the individual consoles are using audio 70% of the time. This means that you have to have an independent audio storage effectively associated with each test most of the time. If that's true, you might as well put the digital and video into the same storage system and have one uniquely associated with each test. Our field is just the other way around. If your fundamental informational system is associated with each disc these things tie in tightly to a nearby computer where you can have a high information rate between the consoles and that logic system and an intermediate store. Your only tie into a central system would be one with a comparably slow data range transfer where essentially the only data you're sending in is the data that Dick wants to check his theories, and things like this. So that you'd have data feeding from this terminal to the central system giving you the experimental results and statistics and whatnot that you want that essentially no information transferred the other way.

DAVIES: Why is is that the need for having a local audio memory implies that you should also have your digitial memory and visual memory and so forth local?

BRIGHT: As long as you can do one, you might as well do all three. It's no more process.

DAVIES: I think they are quite different in kind. The audio memory presumably won't be required to_____________digital. It won't require memory, or a disc, or something like that. There are problems of access timing.

BRIGHT: No worse than audio.

LICKLIDER: I guess this depends very largely on time scale, doesn't it? I think that Dave Evans was thinking about inexpensive logic associated with the console almost in the satellite computer built into the console. I guess it is a little way off yet, maybe even a decade, but certainly in principle, if you can send signals that say what content there ought to be to the audio, you can get a device to generate sounds that carry that information. Until that maybe you ought to have the tape recorder at the console.

EVANS: I think that one may at any time have copies of information locally. For example, at the present time it's not feasible to have a central display console for the reasons that Oliver Selfridge gave yesterday; just too much transmission time. It doesn't mean that the information specifying the picture should not be stored essentially, however. It just happens we have a high duty cycle on this information for keeping the picture from flickering at the present state of the art. Similarly, I can think that for numerical information, for digital information, audio information, we may need copies of this locally but that doesn't mean that there shouldn't be a central facility that knows about these things. Perhaps a service to distribute initially certainly would allow them to be operated upon by the individual users to whom we refer some local user. I don't care if there are multiple copies and all sorts of things, economical reasons. A number of people in the system can have access to this common information for various purposes, and I think that forces its own essential directory system. I don't know what the implementation is going to be but there has to be a means by which many people can get at these things for various purposes.

LICKLIDER: Just one small thing to supplement that. It seems to me that there is a much simpler channel structure to elementary education than there is to college and graduate education. It's quite feasible at the lower levels to make up the tracks, can them, and put them out into the field, but how would you every think of the right things to say to a college senior and pre-record them?

SAUNDERS: I've heard some discussion of financial support or of cost and so forth. I would like to hear a little more on the magnitude and sources. Are we into a magnitude problem where the support for this kind of work is going to intersect the gross national product in 1971? Or is it within the realm of possibility and feasibility in terms of our economy to be able to do the kinds of things which we aspire to do? Would anyone care to comment on that?

LAMBE: I'm rather reluctant, but here is one criticizing point of view. We are talking about the economic instruction. I think we have figures that tell us student year instructional costs plus all those other things which take care of students at the college level range from somewhere between $1,000 and $3,500 per student. Let's just take the figure of $2,000. Then one could ask what fraction of that woujld one be willing to accept added on in order to cover these costs? Certainly I would guess that it is reasonable to assume in the initial phases that these would have to be added on and perhaps not even so unreasonable to suppose they would constitute a permanent increment in such costs. If you'd say, "Well, perhaps the economy could take ten percent as an increase". That does give you a figure for student year, say roughly $200 or $500 or something like that. But at least at that point the question becomes "What can you do which is important in all this for something like $200 or $300 per student year? And that kind of focus I would like to hear perhaps Dr. Licklider lead to. That somehow poses, to me at least, a much harder problem in planning.

LICKLIDER: Let's talk about amortization first. In a rapidly moving technology you don't dare amortize over a very long period; five years perhaps, not more. So you're saying a capital investment of $1,000. This is just about the capital investment in transportation to and from school so maybe it's not too bad. Each student, if he didn't have a couple of hours at the console each day he was being intellectually deprived since through type-scheduling you fix it so that ten students can share one at least. That gets you up to $5,000 investment in supporting apparatus.

GRUBB: $10,000.

LICKLIDER: $10,000? Well, all right. I think there's one computer now you can buy for that; the console doesn't come with it. I think that makes it hard, but it doesn't make it impossible. At that level you can make a nice system with the current technology, I believe.

KOPSTEIN: I want to say that I disagree with the short amortization period, because if you get a system-hardware, software, everything, which is capable of doing something useful--you don't throw it out after five years just because there is a better one available. You can buy the better one in addition I suppose, but you can quite well still use the old one until it literally wears out its lifetime. I think that's a better way of amortizing with some compromise between the two than to merely assume that the normal rate of technological obsolescence often determine that.

ATKINSON: I want to comment on a factor I noticed just about three months ago. The first accelerator in Berkeley was a useful tool for about 12 years. It was finally dismantled. I think there is a little different notion here. Even for experimental purposes in research and psychology when you've got an on-line system working, the computer scientists may come up with some awfully clever ways of disproving it, but you're just so happy to have the on-line system that is meeting your needs that you're well to stick with it for a much longer period of time.

SAUNDERS: Just for the record, the accelerator was dismantled and shipped to Davies!

LAMBE: I think it is of course amusing that such instruments as that can be useful for such long periods of time at one institution or another. I would point out that subsequent models have been built in a shorter period at Berkeley itself and also I think that kind of thing is not very good as a model for what one ought to take. I think a much better model is to look at instruments and machine complexes which are much more in production, much more heavily involved in ongoing processes in society. I would think that the people who have industrial experience would speak with some vigor to this point. I have the impression that that period is quite short in telephone systems, and perhaps the defense industry are reasonable models.

BRIGHT: In Westinghouse, which is a fairly major user of computers, the average life of a computer is three years.

GERARD: Does the thing go somewhere for further use?

BRIGHT: We only rent them. I can't figure out what people do.

MILLER: Researches on developing their systems can demonstrate their true educational effectiveness in elementary and secondary education, and it seems to me that the costs are problems for the Office of Education and for the local school systems. If the "Great Society" is going to take on a real effort to improve our education, and if they are willing to put in sums of money comparable to those which have been voted by the last Congress, both for Health and Education, then it seems reasonable that a great deal of money would go into techniques which would improve the thinking of our students and also of the access of the students to the top teachers in the country. The Heart, Stroke, and Cancer Bill, just for one range of illnesses is $100,000,000 this year; $200,000,000 next year; $300,000,000 the year after. One of the purposes of this is to bring the consultant or the expert, directly to the bedside of the patient by communication technology, ultimately having the super consultant, Michael Debakey, having access to every patient's bed in the country. You're talking about something similar, bringing the best teachers and teaching methods directly to the students all over the country. I don't see why the Office of Education shouldn't pay for it.

MURNIN: Let me direct myself to this question. Up to the present time, and I can't speak specifically for the last legislation that has been passed, the Office of Education has not supported research and development hardware. In my particular program, and I think I speak for cooperative research, which was old Public Law 531 and also the Vocational Education Act, we had specific restraints in what we could support in terms of equipment, in terms of research proposals. One of the criteria which we applied to proposals was that of facility, this being one of the major criteria. At the Office of Education, we expected the university or the institution to supply adequate equipment and adequate facilities in order to pursue the hypothesis to which they were seeking answers. Now under Title VII we could support, under a formula, off-the-shelf items. This was a rather small reimbursement to the institution. Actually this formula amounted to 20 percent of the retail value of the equipment per year for the life of the grant. If it was electro-mechanical in nature we could go higher in terms of either purchase or rental because of the short life of the equipment and the fact that if the equipment were to be rented, it meant that the manufacturer had to get out a larger amount of his investment. Another rationalization we had in Title VII in terms of equipment was the fact that we did not desire to get into the equipment business. If we bought the off-the-shelf items per se they became government property. Now this, of course, is open to interpretation in how they would want to go in either selling it back to the university, but it's a very involved process. Our function and mission was not to take equipment back or to send it to depots for disposition but to have the immediate equipment remain in the university or the institution and to be utilized. What the position of the Office of Education will be in the future in terms of warranty money I certainly cannot speak for. This is something that will have to be determined by much higher levels than myself.

RIESER: May I ask one question about this financial matter? In how many universities today would you guess the expenditure for computing is in the same order or exceeds the expenditure for library? Take the University of California. I'd be interested to know whether a measure of the university budget involves computing endeavors. How does that balance with the library?

SAUNDERS: One of the real difficulties of the University of California is how do you account for computing? For example, at Berkeley there is the regular computing facility on the campus, but in addition to that the Radiation Laboratory had a large computing facility, in fact one of the largest in the country, and that siphoned off a great deal of the research need for computing facilities. In addition to that there are a large number of departments and small computers at Berkeley and this siphoned off some of the need. It's hard to account in other words.

RIESER: Is computing within the factor of 10?

EVANS: Some of the people at NSF who have to do with providing a substantial amount of money that is used for computing facilities have tried to sell the idea that the universities should spend 20 percent as much for their computing facilities as they do for their library and a few have reached this level.

SAUNDER: Wait a minute now. This is university funds; this is not sole operating funds.

EVANS: We can figure this thing out though, far better than a report or a magazine. How much does the library get?

RISER: I can't answer that. I don't know.

TONGE: I just want to clarify the question: We were talking about university contribution or total budget. University of California total budget and non-university contributions.

RIESER: For a computing center? On the other hand I'm sure that there is a man at the University of California who is in charge of overhead. This is just to get a sense of whether the level of computing activity, I don't particularly care where the money comes from, is approaching an order of magnitude or the same as the level of the library. This has to do with the gross national product. I think it's well below university libraries.

MURNIN: I'd like to interject another thought here in relation to legislation and the Office of Education. When a piece of legislation is passed, was the initial task for the Office of Education to try to determine what was the intent of the Congress in the relationship to the Office of Education carrying out its mandate. We know, for example, that the Department of Defense supports large quantities of research and development work, but this is their mandate. When you think of the Office of Education and you think of legislation then you have to look at the legislation and try to determine from its language what the Congress has intended this to be and how far the Office of Education can go in terms of carrying out the wishes or will of the Congress. I think, and this is a personal observation with some of the legislations with which I've dealt, that this has not spelled out. Now as you know, many of the legislation acts are open to interpretation. My own particular stand which I operated under for a few years was open to interpretation in certain areas but in other areas was very specific and they spell out exactly what you can do and our lawyers will say "no, this is it". The law is very, very accurate and specific at certain points. I think that we have to think of legislation in this framework, how it's interpreted by agencies who carry out these legislations.

BRIGHT: I don't think industry is too different from a graduate school in a university. We have about 600 professionals, 250 of which are masters going for their Ph.D.'s. We have library facilities that have been added to local universities and I've just made a quick calculation here. We spend considerably more per month on the computer center than we do per year on the library.

MITZI: I want to go back to the question of implementation of CAI in elementary and secondary schools. If we assume for a moment that the description that Miller gave that the U. S. Office or the government might pay for implementation, assuming that doesn't come to pass, I think that in elementary and secondary schools there is going to be a real problem. You figure 60 to 70 percent of the local school budget goes for school personnel. This means that there is a kind of frozen quality about budgets. There can't be any wholesale firing of half of the instructors in order to pick up the check for some equipment that has some unknown quantity. It's my belief that the best way to implement CAI is to bring it in piecemeal. You start letting by CAI do the jobs that are least well done today in that setting whether it's elementary or secondary schools.

Atkinson's work on reading I think is a good approach. I think reading is not being well taught in general. Foreign language instruction is another. Instruction for mentally retarded kids is another area. It has to be a gradual, evolutionary process instead of a quick coup d'etat.

GERARD: A few years ago the estimate was that they were running 150,000 teachers short a year of the need. The price of that, even counting their salaries alone is about $3,000,000,000 a year but we don't have to wait to get rid or personnel if we could turn into other resources, if we could find them to replace those teachers.

MITZEL: You can take a look at some of those proposals under the new elementary and secondary education act. What you find is that public schools are proposing to do more of what they are currently doing. There is very little in my opinion of bold, imaginative kinds of thinking. What that means is if they have 50 teachers today working on their instructional staff and they can get a little bit more money they are going to hire five more to supplement what they are doing. This is the way they will tend to operate.

GERARD: I'm afraid you're right. You didn't have to wait for firing teachers.

STARKWEATHER: What's worse than that is in the State of California there is a state law that 50 percent of the school district's budget has to be spent on teachers' salary. You see school boards sitting around and discussing how can we get rid of nonteaching chores of the highly trained teachers that we have and that they are faced with a requirement of that sort to take into account.

SAUNDERS: I think Lou Bright will agree that the addition of computers to the Westinghouse Corporation hasn't reduced their total operating budget one iota.

DAVIES: I believe we should talk some more about the political ramifications of what we're all saying. We are talking about instituting extremely sensitive systems over the country at the elementary and the higher educational level. There are a lot of political implications, in particular what are the proper set of attitudes for us to have and actions for us to take, as the leaders in this kind of thing, in order to promote this cause and to get the country to invest what we regard as the appropriate kinds of investments? I don't think that this shows up formally in the agenda anyplace but since we are all gathered here it might be worthwhile to talk about that. I don't know who else is going to go to bat for this sort of thing if we don't, so the question is what is an effective way of going to bat for them. How can we have a strong influence on the people who make decisions about the funding of such a program?

FLOOD: Just one possible way that I would like to mention. I'd like to use the time-sharing theory first. For example there is nothing really new in the last few years about the fact that time-sharing could be done and I'm not sure that a great deal has to be learned about time-sharing as a batch of hardware so to speak. What I have in mind is the following. I think that we've learned two lessons. One is if you want to get something moving, as was done by supporting those two major efforts and by a few of the university programs around the campuses, you must get something going with bright people using it. The second moral that I think we've learned from that is when you do that, you learn things you didn't dream of, and the on-line intellectual community is a major example of that. So I think that one thing that we should try hard to do is not assess cost benefits at this stage of some of the interesting systems. I think that's wrong; that we'll miss the boat.

LICKLIDER: There is a question that I think is very interesting that we haven't discussed, and I would like to go forth for a moment on the subject of adaptive models. There are many interpretations of that phrase but consider that the time-sharing systems themselves, the one-line interactive computing system is a thing that can be modeled within itself. The model can be attached to the working system, that is the parameters of the model can be controlled by the record-keeping apparatus of the system. I don't know of any less complex system that offers such an opportunity to study, perhaps concurrently several alternative models letting their parameters through some sort of adaptation with those of the actual operation. This whole thing extends itself to the network concept that we'll talk about later.

A second kind of use of adaptive models I mentioned in connection with dynamic modeling was a package of services to be afforded within the time-sharing system. I will say here I think that is the greatest single value in the whole discussion--the value of dynamic modeling as an adjunct to an extension of human thinking, but I can't go into that and try to dissolve it or justify it.

Third, there is of course the adaptive model of the student, the user of computer-assisted instruction. I regret that I left out of my complicated diagram a few parts. One of which was the part of the data base that contains the records of the performances of the students. But of course that's an essential part of the whole thing; the coupling of that to the whole administration of the school. I see here a tremendous opportunity for the development of models of students, even individual students, modeling them in detail and then using those models to control the flow of instruction, the flow of experience with the computer, also in an experimental way, to try instruction on those models if you don't mind carrying this a step farther only to see if you can't develop sufficiently good models of students so that you can determine in advance the relative applicacies of two or more different ways of providing the educational experience.

ATKINSON: I'll have to agree with that. I'd like to say that I think that in certain areas, especially in the lower grades, we have the tools around to really start doing some good modeling jobs. I'd like to raise a slightly different question. I think it's been very clear and everyone has agreed during the last few days that as one moves from the lower grades up to the college level, you get more and more of a fight between this one extreme of the Dialogue System and the Drill and Practice System so that when you're at the college level, one just isn't much interested in Drill and Practice type systems. The next question is how does one divide the research and development time over the next five or six years? Should we really be worrying about developing computer-assisted instruction at the university level where we are going to be necessarily confined to less rich interactions than we would like. Or should we really put our development effort at the lower-grade level where we have a good feeling at this point in time that the interaction possible is rich enough to really do a good job in these areas, and furthermore, we know that by development in these areas we we are going to be able to come to grips with some of the behavioral problems in the lower grades that, in terms of an analysis of the behavioral problems at the college level, might be just too tough to tackle. So really I'm almost just to the point of throwing out a sour note in terms of the organization of this conference; possibly we shouldn't be worrying at this point in time about developing CAI systems at the college level. We should let that remain still very much a research effort and make our real development picture at the early grade level. I don't want to curtail research on the Dialogue System. What I'm saying is that the essence of the breakthroughs in this area is that we might be well advised not to push for elaborate developments. Now Dr. Mitzel may not like that comment.

SAUNDERS: At this late hour does anyone wish to rebut or comment?

KOPSTEIN: Dick, may I disagree with you, with two major reasons: one, I think the college student is a much more mature and flexible organism and can tolerate a much more deficient system and views it profitably than at a lower grade. At a lower grade I think you have to have a far more perfect system before you can truly entrust a student to it. The second one is that this is a real consideration in a real world. At the lower grades I think you have a far stronger and a far larger vested interest in the status quo than you have in the university. I would like to suggest that this is a very major consideration.

BRIGHT: There are two points that I want to mention that Dick didn't, and the other one I want to disagree with him. The one he did mention was the direct instructional cost in the elementary school as 27 cents per hour where as in the universities it's something like $2.00 an hour. But the economic environment is quite different. The other one is I don't think I quite agree with him that the university level courses are not as adaptable to this kind of mechanism as the elementary school. I think that courses in elementary calculus, physics, chemistry and so on are extremely logically organized and are very amenable to conventional programming data techniques. I think the computer could do a very effective job.

LICKLIDER: If you are enthusiastic about the potential, about the benefits to be achieved here, if you are in zealous, you can look at this in the following way: It's really going to help people be creative. It's going to help them do intellectual work. It's going to be a benefit to the nation, to the world. How do you maximize benefit? That has a lot to do with the turn-around time, with the generation of people who can use it. Do you use this on graduate students, on college juniors and seniors who are going to be plowing back their increased capability in two to four, five or six years, or do you do it for first graders who have sixteen, seventeen years before they start to be regenerated? I do feel that way about it so I have this bias toward using it where it will have its effect earliest. The second point is that the thing we have the hardest time doing in the world of computers and programming is to incorporate heuristics into computer program. For computer-assisted instruction of very young students who aren't very capable heuristically themselves, it is necessary to get almost all of the heuristics into the computer. But for use in college and graduate environments where heuristic capability is overflowing all around you, it is necessary only to make available some good algorithmic capability in the computer and it can be put together and made into a workable useful system.

SAUNDERS: I think this is as good a point as any to stop. I'm sorry that Rieser got away because much of the data that pertained to the cost of libraries versus the cost of computers can be found in the public literature and such data can be incorporated in the material that is finally issued from this conference. On that note I thank you for electro-stimulating our discussion this afternoon.

GERARD: I want to generalize that last comment. When the transcript of this comes around to you, if you have any material to add at any point or additional comments that you would like in that didn't get in, please insert them.

Thursday, November 11, 1965

SESSION V

9:00 a.m.

Administration - Integrated Records and Procedures

Speaker: James F. Blakesley

Chairman: Kenneth W. Ford

FORD: I will call the morning meeting to order, please. We will follow this morning the same general format that has been working successfully in previous sessions and begin at once with a brief review of yesterday afternoon's meeting by Louis Bright.

BRIGHT: Summarizing yesterday, CAI has been primarily concerned with augmenting the two teacher-textbooks interaction. Programming a computer that is dedicated to that function alone is an interesting but straightforward task. However, there is a complex spectrum of other types of interactions on a university campus and between universities. To bring the potential of the computer to play requires a large central machine having a very large abstract memory and data bank. The executive computer programs for such a system are straining the present state of the art. Computer specialists are solving it. When such a complex system is available it will have the entire hierarchy of languages. In spite of the system's complexity, a high-school teacher could write courses using nothing more than a Course-Writer-like language. However, to take full advantage of the system, college students and teachers should learn the details of all of its capabilities. The various languages will constantly evolve to eliminate their restrictions. These individuals, however, would never have to get involved in the complex details of the master executive and dynamic memory allocation programs. Such a system excites the imagination because it can include contributions from the entire on-line intellectual community. Thank you.

FORD: Today's session will be regarded by educators as less exciting than those that have gone before us on the subjects of the computer in the teaching process and the computer in the library. Today we're concerned more with administration. A compensating advantage to today's session, however, is that there's been a lot more solid progress in this field. We're in a less speculative area, and can see more clearly the advantages the computer offers and what lies ahead. I've listed on the board three areas of administration-computer involvement that might form a skeleton for the discussion this morning.

(On board): ADMINISTRATION-COMPUTER INVOLVEMENT

1. Administration of computers
2. Administration with computers
    A) Student Admin
    B) Admin Admin
3. Administrative problems created by computers

FORD (cont.): Let me jump at once to the second on the list -- administration with computers. I think that is the core of the morning subject matter and the heart of Mr. Blakesley's talk. Under that general heading we have student administration, which includes the admissions process, the enrollment and scheduling problem, the registrar-records problem, and the alumni records problem. We also have the administrative problem, and this is the subject which really constitutes the core of this afternoon's session. I think we should try to omit that from the morning discussion. Under that general heading we have things like financial records, faculty records, donor records and so on.

GERARD: Ken, the afternoon session is intended to deal with the university as a system and the kinds of information flow that should go up to top administration. These other administrative matters I do hope will be included in the morning session -- the bookkeeping, the records, the inventory, everything of that sort. So if you don't mind, please do not exclude it this morning.

FORD: Items 1 and 3 on the list are things that we might also think of getting into today, although I believe they're not matters that are of main concern to Mr. Blakesley. By administration of computers, I mean such problems as where does the computer fit into the structure of the university, how is its operation financed, and how is its priority of use determined? Under class 3 type problems -- those introduced by computers, created by computers -- I include such things as the support of programming teams -- the groups that will be creating the curricula materials. In general, I have in mind here those administrative problems connected with the use of computers as tools of instruction. The problem of assigning teaching credit for programming work, the problem of assigning teaching credit for teaching courses with computers, the general royalty problem of reimbursing the man who creates the material and reimbursing the institution which supports the creation of the material, and finally the data, problems associated with the administration of students when computer-aided instruction becomes a large factor. This includes the problem of flexibility of the student's course-load, his variable rate of progress, the variable timing of examinations, the set of problems connected with more challenges and more opportunities, and problems connected with the possibility of introducing different units of measurement into the student's progress toward a degree. Well, let's turn now to our major speaker for the morning, Mr. Blakesley from Purdue University.

BLAKESLEY: Thank you very much. I am going to use a few graphs. I will restrict the remarks to some concepts of the total system, but in general I find that scheduling is involved in the middle. When I've gone around the United States, I've found the use of computers in administration being quite mixed. We've gone to punched cards, we've copied what we did in manual form -- now we've converted manual form into punched cards and into the computer-tape system. But in all of this I have seen very little in terms of the philosophy and change in the management technique relative to new ideas in processing this information in a way that would provide management with the full order of plan, execution, and review -- the execution being the scheduling of the students, the staff, the resources of the institution, and a review to find out if you really attained the goal to which you had addressed yourself. This data bank that Licklider talked about, as we will develop later on here this morning, includes staff resources, and very few institutions can tell you off-hand how many staff they actually have on campus, although they report it to their state agencies.

The space problem is a real comedy. We say, "well, this is easy to get at, how many classrooms do you have?" You walk around the campus; people say that there's a shortage of classrooms. You go out, no problem; you walk into any room at any time and very few students are there. What is the true utilization of space? Let me just diverge here a little bit -- are there too many toilets at your institution? Why inventory toilets? Isn't this just as much an expensive item, something like $25,000. Purdue University has four acres; we can almost seat everyone at the same time (ha, ha). I raise this because there are theories, such as a queuing theory, that are very applicable! You go into an academic facility and you just walk down the hall a little bit and you're there -- have you ever waited too long? Here's a measure. How about half-time at the football game? Well, the ratio there is something like 1 to 500. In an academic building it's about 1 to 40. How did we get here? Probably the primary and secondary school code in the legislative sanitary code have progressed into higher education, but nobody's taken a serious look. As a result our going ahead blindly to an inventory of toilets...this became a serious consideration. But we'd like to spend that $25,000 for a teaching laboratory.

These are the kinds of concepts in higher education to which the administration should be addressing itself. The computer is an aid to this. Let me divert here to describe first, our program

PASS (Purdue Academic Simulated Scheduling System) and the philosophy behind PASS. PASS results, by-product management reports, and space impact, then I shall describe my next and most important part, CUSS (Comprehensive University Scheduling Systems) and there is another one, CRISP (Cooperative Research in Interinstitutional Space Planning) which is at the University of Wisconsin, a computer-oriented technique for estimating future physical facilities. This was described by, in a way, the impact of not having enough room in a computer, so please plan space to grow when you get your next one. As soon as a student graduates from high school, he gets into higher education. Now, in the construction of the master time schedule, which is the time of all university resources, we come up with the philosophy that if everything were to be taught at one time, all courses at one time, the student could take only one course. The staff member could teach only one course. Every course would have to have a different room. Now, recognize what I'm doing here. I'm putting everything in at one time. Monday at nine -- isn't this when everybody would like to teach? All right, now go to the converse; everything is going to be taught at a different hour. Now an institution such as Purdue would have 2,000 hours of instruction if each course had only one hour, because we have some 2,000 courses. If everything were taught at a different time, conceptually, a student could select a course at any point in his curriculum and not have a conflict with another course, he could select any set of courses, or all of the courses. If a professor had the capabilities, he could teach this and it would only require one staff person and a room, so adaptable that one room could serve all courses. Now, as the schedule is compacted, and we go from this 2,000 hour week down to a 54 hour week, down to a 44 hour week, and, if you will, down to a 20 hour week -- what we are doing here is reducing the course selectivity on the part of the student. We get it down so that (1) he can take only one course, so the challenge here is to investigate the curricular requirements of the student and provide an academic program that will allow for course selectivity on the part of the student body. Many times we've gone out and done some studies for schools, and we've found that required courses are being taught at the same time, not just at the undergraduate but also at the graduate area. The plan of attack is something of this nature: "When do you want to teach, Professor X? When do you want to teach, Professor Y?" Not when should you teach this course so that it does not conflict in terms of course requirement in terms of the student. So we at Purdue have taken the standpoint that we are going to distribute our hours completely, we are going to have choice of hours being secondary to choice of curriculum. We feel that the student should have first of all, a chance to progress at his own rate, whether he is fast or slow. We feel this is more important than his being free on Saturday. Now, we're not backtracking to the point where the individual does not have any choice of hours completely.

We hand him a schedule of classes, free times, if you will. The athlete finds Intercollegiate Athletics 700 listed just like English 101. The musical organizations, the Glee Club, are in there; the waiter service in the residence halls; lunch hour requirements -- we've got distance problem. These are compiled right in the computer, with two hours of lunch hour breaks for those who have a distant resident hall to go to. The necessary element here is that the student is given free time because of a need, not because he just chooses to have his schedule Monday, Wednesday and Friday at 9. The University of Massachusetts wanted to design what you would call a good schedule. I have never yet found a good schedule for a student. Academically, the faculty preferred to try to distribute the preparation time over the week, as long as possible. In other words, each day the student goes to class he has preparation time for the next period. At the University of Massachusetts they tried this, but they found out that 50% of their students rejected on the computer. Why? Because they had concentrations of their classes on Monday, Wednesday, and Friday and not enough classes Tuesday, Thursday, Saturday, so that Tuesday, Thursday, Saturday courses were filled and the end result was that the combination of classes were limited by the closing of the Tuesday, Thursday and Saturday sessions. The impact of this was that they had to shift their courses themselves to Tuesdays, Thursdays and Saturdays to allow for the selectibility and for the purpose of this philosophy. We have attempted to have the students processed on the computer.

We are going ahead all the way from undergraduates to graduate students, first semester, second semester, summer school, advanced registration, regular registration, drop and adds -- the whole operation is on the computer. Prior to this time we were in trouble. We could never get the management reports out, drop and adds became a fiasco. (SLIDE) We began the research work in 1956-57 and here you can see the results. We're still not reducing drop and adds, although we have something like only 240 students that after the beginning of classes are changed completely in terms of their courses. We're up now to 20,176. The general pattern that you see here is still consistent -- we need something like 30,000 processes to get 20,000 students scheduled. And I don't believe we want to be restrictive to the faculty or student body that would not permit change. So we're interested in allowing change. If the faculty member wants this student to change from this course to another, shift his curriculum for his benefits, this is his privilege. That gives a volume implied in terms of sequences when we process. Here is the situation in July and August. I intended to try to keep the students from ever having to go through a line. During the second semester, we proceed to get the course elections, then we schedule the students during July and August, then send out an invoice, which is the last copy on the material you have here, which is already receipted, and the student sends this back with his check. The check is received, the top copy is then receipted, and he has a receipted schedule which is his admission to classes. There have been students at school at Purdue who have gone all the way through the four years and who have never done anything but take care of their registration in their advisor's area, have paid their fees in this fashion and have attended their first classes. They didn't come a week early, they didn't stay between classes, they went home or did whatever they wanted. The intent here was to be able to begin to operate Purdue on the first day of classes and proceed to minimize the cost of putting all the residence halls in operation a month or two early. That's an excessive statement. The incoming freshmen students were brought to the campus during the summer months, during freshmen week or freshmen day, and one day apiece the parents were invited. They went through their testing, they were assigned to their courses and they were a part of the same scheme. During the drop and adds normally it's only about a week in length to process a minimum of schedule changes, but we have accomplished quite a deal before the beginning day of classes. We encourage them to come back. One of the things about the invoice voucher is that they don't see their schedule. Originally we had NPR paper, and the students are pretty bright and they found out that you could dip it in coffee or iron it and you got your schedule. The bursars found that if they don't see their schedules they pay their fees faster, so we had to shift to this particular kind of paper because the students outguessed us.

(SLIDE) Here is the same sequence of operations during December. We do them in batches of five to six thousand. From computer into computer and out we can do about 12,000 an hour, but we do them in batches and work right with the research computer. We don't have any problem at all with the Computing Science Center. The time increment is small. We might go on at midnight, but it's a matter of only a short time on the computer and we're back off again. I would not recommend putting this particular function on a small administrative computer. My feeling is that I want to devote as much as possible of the resources that I have at my command to the Computing Science Center and continually upgrade the equipment to the biggest and best facilities that we can have. This is just a technique inside the construction of the master schedule. We have as far as we know almost all combinations and schedules, one-hour, two-hour, three-hour, and four-hour labs. We have split the day at 11:30; the lunch hour bits are inside the computer and they will restrict any undergraduate student from having no lunch hour. We have had the situation where the vice-president's wife had to have a particular course and section and we were able to accommodate her; this is a necessary element. The resident hall scheme has worked in; we'll have waiter service in the resident halls which will allow the student to have time off in the midday. This forces the student, logically, into early morning and late afternoon if he has employment at the noontime. We had a situation on Saturday classes, where all of the special requests go through the Dean of Men or Dean of Women. We found that one clothier downtown had released letterheaded letters requesting that 40 students have Saturdays free. When we investigated it we found that he was selling suits: "You buy a suit and I'll give you a letter," so you have to be in control of these situations.

(SLIDES) This is to give you the volume, schedules rejected, of second semester last year -- we recognize we still have not planned the schedule in any optimum fashion. So we have constructed the schedule as best we can in working with the academic department heads and deans and as a result of the feedback we have been able to improve upon it each year. 701 students were rejected and 18,000 were scheduled.

(SLIDE) What this was was the number of passes going through and it's a qualified reject rate. I've been at schools where the reject rate was 20%. When a student sits down and makes a course selection he goes through the computer and he has an 80% chance of getting through. In this particular program he has about a 95% chance. It's the same way with drop and adds. We continually balance the section sizes, and the reason for this is that we want the last student through the computer to have as much chance of getting the courses he wants as the first. In normal registration, what do you have? Fifty or 60% of the student body goes through and then 20% of the sections start closing, then 30%, then 40%, and pretty soon the last student in can't get the courses he wants. Now this is the problem that prompted computer scheduling at Purdue.

We had 500 freshmen engineers who on the first day of classes couldn't get their courses. The first 700 had made sure that they had morning classes, no Saturdays, no afternoons, and the end result was that the combination of courses and the divisions that were still open did not enable the students to get the courses they wanted. Then we shifted to what did cause the rejects.

(SLIDE) These are some of the management reports that are coming out. There are still conflicts in hours--we'll then analyze those particular courses to find out if there is a pattern of student rejects, so that we can improve the next term's schedule. We've simulated in advanced mathematics the second semester after students have been programmed to their courses and decided that they will shift from a small recitation to large lectures and seminars. We proceeded to change the master schedule, put the student through, and find out if this would work, and we found it could be done so we proceeded to modify the master schedule and go ahead and schedule the students for this program. We've also gone to a point of three three-hour labs a day in chemistry, and the Chemistry Building will be programmed on a 48-hour laboratory utilization. We tested this on the computer to make certain that it was feasible, and it was, so we've gone ahead. All of the students' records now are being kept on the magnetic tape so that we can go back and test the theory. Closed divisions are becoming minimal. We're keeping them open -- they don't cause a serious reject rate. The lunch hour is just as dramatic as the closed division. Drop and adds are about the same. Now of big importance to those who want to get classes started on the first day, and do not want to have to have classes reorganized every week, during that first week or two weeks of the classes, we have attempted on the drop and add routine to minimize the student who's coming through for a change in program. If he wants to drop one course and add another, we keep his schedule. This remains, and we drop that one course and attempt to add the new course and fit it into a section that is open. We've had success to the point that only 2.4%, or only 388 students out of 17,306 second semester last year, had their schedule completely changed. In addition to these we have free-time requests. These are students who request for employment and so forth, where their schedules were changed. They put in a free-time request; this is a necessary element of saying "I want a significant change -- wipe everything out and start over." Then we have the predetermined request where they want a specific instructor. This is in there. One of the sidelines that we have been working on now (we have never permitted a choice of times to any great number) we have now put into the program a choice of professor, and our reason behind this is to provide the academic environment that the faculty wants. Now it's sort of a comedy of results. We want to have, and we have an opportunity for 800 students to select various English courses on the basis of choice of professor. Only 80 students made a selection, and 80% of these obtained the professor that they chose. The number is not getting any bigger. We are not getting faculty members who want to do this because they feel that there may be a professorial preference scheme being built into this, not from our standpoint, but the students'. The question does come up: "Is this professor better than so and so, let's all elect him." So his class size goes up and therefore the other professor's class size goes down-- why is this one professor better than others? History, government, and philosophy, the departments which we felt would be significantly benefitted from this plan, currently haven't pursued it because the freshmen don't know the professor that they would like to choose. In the graduate area there are only single sections, and you take a professor with a course. About 10% of Purdue's course offerings that are between, let's say, two sections and ten sections, where this is a very important part and should be augmented into the program. We're encouraging it and we're hopeful that they will take advantage of it.

(SLIDE) This is another array of the same information again pointing out how many students kept their old assignment. This program is about three times as complex as the regular scheduling routine. Basically there is about one student that drops and one student that adds in a section of 30. This is the impact of this particular program. Similarly, just quickly giving you the same information on a subsequent semester, 388 dropped or added after the beginning day of class. Some of the by-product reports, of course, are checked to see how well we have scheduled in our projected scheduling -- in other words, how far along are we in the scheduling routine at any time through the semester for which we're doing advanced registration. You can see quite a variation relative to the registrar enrollment figures and how many we have already scheduled and what the projected figure may be. Graduate students tend to wait more than undergraduate students. This is completely off the computer, but at any time that we want to we can send the Registrar and general administration the total array of students already scheduled, or as an end result after the first day of classes, the whole enrollment breakdown.

We're still loaded with men and not so loaded with women. The program schedule revision requested where we're studying and finding out if there's a particular school that is significant in the number of changes, and if there is anything that is high -- and there are some high ones here -- percent revised in the humanities and the junior sixth year was 66%, while of the 62 students that went back a few of them drop and add show 94, and this may be one student going through five times, but it's still significant. At times I say "Well, is advance registration all worth it?" and I have to keep repeating to myself "Yes, it is." Probably it is if you get as much of the paperwork out of it as possible, because it's processing the drop and adds now at a somewhat minimum of cost and expense, and we can make changes rather rapidly, and you can get the fees paid and the other miscellaneous material all taken care of. We studied in addition the closed divisions and lunch-hour conflicts to see if there was an array here that would lead us to a better and improved schedule. We can cut off with the computer any time we want with an array of students that are in class at any one time. This particular one is by hour. and we operate from 7:30 until 5:20. 7:30 is the lightest hour we find under this manually scheduled scheme and 4:30 surprisingly is still pretty popular, even more so than the lunch hour, which we are still working with. Less than 50% of the students are in class at any one time and normally it's about 60 or 75%. Giving these in a different array, here is the distribution on Saturday. About 5,000 of Purdue's 20,000 students, or 25% of the student body, are in class Saturday morning at 8:30. This has had a significant impact politically because we are indicating where the students are and at what time they're in class, and that we're not queuing all at one particular time. The evening classes at Purdue are minimal, primarily due to the fact that we are now having night examinations, from one to two hours in length on Tuesdays, Wednesdays, and Thursdays, six weeks during the sixteen-week term. This is for the purpose of unit examinations, testing all of Chem. 114 students, of which there will by maybe 2,000, and then getting test results as a by-product of this. Some partial analysis given here is a little bit into another form of administration. I don't know how many of you filled out this form, or how many of you had other members of the faculty say, "I filled out a staff load; I filled out a space utilization; I filled out an enrollment report; I filled out my class list; now what else are they going to have?" You get a staff load report and and individual says "80% of my time is spent filling out administrative reports." This is typical of the way in which utilization studies are made and typically we find that they are just loaded with errors. What we have done is go to a mechanism of class organization reporting in which the by-product of the scheduling of the total environment here, the class, the type of class, the time being offered, building room, number of students, and the contact instructor are all recorded on one sheet.

(SLIDE) This is a preliminary program of about two or three years ago to come out with room utilization automatically, and this is a primitive one from 1957-58 when we were still on card-oriented machines with some computers. Now we're coming out with this kind of general array, and the figure .4 over on the right-hand column is the only figure we look at in terms of a management, by exception as that figure approaches 1 we know that the utilization is pretty doggone poor but it's equal to national standards. .4 is a very high utilization -- this is a typical schedule for 63-64 in our primary classroom building, Hevilen Hall, and you can see here that the utilization at this particular time was 45 hours during a normal academic week. The same information sorted out again by a staff member and loaded on in a staff data file gives you his work-load and he goes out and he can verify it or the department head verifies it and comes back. The staff member now no longer sees this and is involved with it -- the head of a department is the only one who can make a commitment of how the staff member is using his time. Along with this we come up with a statistical report which shows trends relative to growth in the department and individual instruction percent and the number of faculty members in the various categories.

(SLIDE) The current view of the computer program is very similar to this -- this is the class organization report, now off the computer, with all the details that you saw previously, and the staff members' listing or tape would look something like this. We're expanding it to include courses and you come off then with all of the state-wide studies and how many head professors, associate professors, and all the rest are required. Very few schools have this, and it becomes quite simple after you get the thing programmed. Here again is the staff member's load. You'll notice that no longer is the individual instructor on there but just the department heads. The times -- days and hours -- are not essential because we've got them already inside; all we want to know now is allocation of time and the records so we can support our budgetary requests.

(SLIDE) Likewise, when we are after the same utilization studies we can come out with reports which would indicate the use of all rooms in the particular building, whether they be classrooms or laboratories. Again this column over at the right is a significant figure of exactly how the use is going on. We've found, for example, that a certain room has a very poor use of 2.2. Really, that is a very poor room -- the lights are bad, ventilation is bad, so nobody wants to use it. So this is an indication to us to spend money, not to just force a high use on a poor room.

Similarly you can summarize them by building, on the average of how well the building is used, and part of the campus is at a .7 use factor. Then for the total university you get down to a .9 with the North Campus being engineering, the Central Campus being hard science and humanities, the South Campus being agriculture, and remote areas being the Air Force and veterinary medicine. This tendency of concentration in the central part is the administrative function in part. We are interested in concentrating classes in the heart of the campus to minimize transportation time on the part of the student. We're not interested in having them just distributed at random campus-wide so that they have to run for miles. As the use in the heart of the campus is growing we're slowly going more and more to the South and North areas.

(SLIDE) Here are class sizes graphs, and again I haven't seen any dramatic change in this, even though this is a 63-64 data. They talk about large lectures and going to larger and larger lectures, but every time we watch the array we find that when you go to a large lecture you tend to keep more small classes. And at Purdue there'll be 2500 hours of instruction with classes of 20-29 in size. So individual instruction and the small classes do exist; it's just a matter of relationship here. This is a challenge leaning on the building programmers; they are not building too many large lecture rooms. Basically we've found that every time we've made a study the lecture rooms are filled with small classes. But you're going to have to have a classification of every room, including back to hallways. The physical plant now is involved in planning out how much work the janitor has -- we've got close to 30 miles of hallways that have to be swept each day, in addition to four acres of toilets.

(SLIDE) We've found that our greatest shortage at Purdue is offices for faculty and maybe these partitions will work some way. Here is the same thing and you'll notice that here we've got Hanover Hall, which is a new building, so we've tried to design a report which will allow knowledge of exactly what this building contains -- this is one that they refer to when they're dealing with building problems -- and this is strictly off the computer; again it's the advantage of the large-scale computer to do this kind of programming. Now here's modern language the way it is if you look inside a computer -- the codes and everything -- again another line and nobody's going to read that so what we did was come out with a program that says what does modern language have ? And those classrooms are in here because they're general assignments, but now we can relate the staff back to the general office area and find out how well they're being housed. Study hall area, conference rooms, whatever you may have. But we've found that this kind of reference material is quite significant and helpful in terms of general administration. When we got into the capital study we found that there have been errors in our data and we've just discovered them here. We had one building in which the second floor was as high as the first floor. This was criticized by Indiana University; they felt that we were padding the report, but it was just a digit that was off. Until you get down to this point you can't really find your errors.

(SLIDE) Here is the Education Department. It has 11,104 students and they are in five different buildings. This is important when you state dealing with problems of trying to organize the staff.

(SLIDE) Here is the Chemistry Facilities at Purdue. The research building was built about 1900; the Chemistry building is relatively new. We use some of the World War II barracks. A new chemistry building is being built at a cost of roughly $8,000,000. We built a new mathematics building last year; the cost was 22% above the estimated adjusted upward cost of that building. Since that time we have had a civil engineering remodeling project that was 30% over the estimate so that now a staff person's office of 120 square feet is costing about $8,000 or $60 to $70 per square foot. The problem here is significant. It could deter the tremendous impact of new resources in higher education.

High employment is to the point that the individuals are so fully employed that we don't have any labor force left, and they have to guarantee to pay time and a half and double time to the contractors. A $20,000,000 Anheiser-Busche factory is going up in town by next September -- this is in competition with something like $10,000,000 of building at Purdue, and there just isn't any labor force available in our local area. The Big Ten is experiencing this particular thing almost completely. The same thing is happening on the West Coast. It hasn't been as significant yet, but there has been indication that it is going up this way, as I understand it. We won't be able to build some of the buildings that we need, and if we do build them we're going to have to ask for money three times. In some of the NSF grants or loans, if we don't estimate high enough there isn't any adjustment upward, so then it takes more State funds to match the dollars that are available. This is one of the impacts.

You can get high utilization of resources on a computer scheduling. I'm not afraid of 40 hours of use in classrooms or 48 hours of use in laboratories, and I think from a curricula standpoint that this is very apropos because we are going to get better course selectivity. The total percentage of space used for classrooms is 3%. Now maybe we're being too tight.

Now we've gone through PASS; we've looked at the space, and know what the staff resources are. Let's now put them together. Isn't this what we're trying to do in a way, in terms of the total system? Staff resources, room resources, course requirements, student requirements -- how do you coordinate them? We call this at Purdue a bookmaker -- because it has pretty good chances of success. We've had success with it. It's very complicated -- it's a $50,000 project and we're adding another $25,000 to it. It's been a cooperative project both within Purdue University and Chatham University in Washington. You'll notice that PASS is still there to get the students in, but you can proceed then to have your cost data involved; you can get your utilization reports, your space records, class records, staff records, review -- you've got then the three phases of management plan that you can review. Now, what do you need behind some of these elements? Staff, identification and desired load. This whole program is built on the assumption that the individual institution can choose what it wants as its desired load. If you're going to build a master schedule and you're going to assign staff members to classes based upon it, a computer is going to tell a professor when he is going to teach a class. Is this all right? Well, you want a creative management in higher education! The professor is going to have research. You're not going to do research in hour blocks. You're going to have to have four hours. Maybe you've been away consulting, therefore, you are going to need Mondays free or Saturdays free. You know that you can do this and it doesn't influence the academic program at your institution. Why not put in the time restriction? Next desired course assignment: What can the staff member teach? Add to it: What does he have to teach? In certain departments there is a problem because the staff member doesn't want to teach undergraduate students so he lists only those graduate courses. Put the capabilities of the staff member in there. Room requirements, course requirements, time configurations, any configuration that you want. In Seattle they were trying to cut class size. When it was cut too far we found that we had to double their faculty. This is of course a natural outcome.

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Credit -- this is a control. Total student demand -- this is a result of the program of the student, and it could be on an estimated basis or it could be on a factural basis.

Room resources -- here it gets into a resources catalog of facilities that are available in the institution. You want to make certain that you can get the classes close to the staff member's area.

Student requests -- and here is the heart of the whole thing, because this is our whole attempt. Can we build a schedule that will satisfy the curricular requirements of a student body that has tremendous flexibility of election of courses? This is the key area. This is most helpful at the small school where you don't have very many multiple sections. In a large university it's most helpful at the graduate area where it's very expensive construction. Our whole attempt here is centered around this particular thing. It's a demand matrix of student request. Let's look at a little cell in this matrix. Here is the load the staff wanted, which was in credit hours. That's teaching capabilities. The times researches begin were listed . So this is a resource document. These items are very difficult to obtain -- a lot of people have these intuitively in their minds but they can't seem to put it down in black and white. Here is a course requirement concept. The type of instruction -- whether it be lecture or recitation or laboratory. The contact hours is a control. Here is an array of time, and the institution can choose what the pattern is, or your restrictive pattern could be taught only in the morning by selecting Pattern C that only had classes Monday, Wednesday and Friday at 8, 9, 10, and 11. You can design these and make these lists infinitum. It just depends upon the capacity of the computer. You can have 50 minute classes or whatever you want. The classroom center of the campus, this is the array, a language laboratory which triggers the computer to bring in all the language laboratories of this nature of character. Staff load on the full-time equivalent, class size indicated, and so forth. The room arrays have the different kinds of AB rooms, so that if they call for AB this is the particular area where they go. The honors rooms are set aside for a particular group. A room can be in any number of groups and can be called upon at any one of these times. The first time all we did was to get Pattern Number 33, which was the typical pattern, and to suggest they break it down and have any variation that they wished and expand this tremendously. We want the flexibility of course assignment. We want the program really tested in terms of the various demand matrices that would be an outcome.

Here's an enrollment report already printed as a result of CUSS. You'll notice that in English it graded the 19 sections and it was based upon a 25 class size and there are only four or five classes that are 24 in size. So if you needed another session, if you had 25 this would proceed to produce this. This is one of the results. Another result was the staff member's schedule and his load the way they wish it. This is computer-produced. The problem here is what is a good staff member's schedule? We've found that within this you have flexibility of changing staff members and it doesn't disturb the schedule at all. If one wants to change and get an improvement, fine, as long as there's no conflict in time. But you have something already built upon which you can modify, so that you have the flexibility here of making changes. The load on the right is the way they wished it -- those could be appearing in any number of forms. But you now have the staff member's schedule, the student's schedule, you have a room schedule, you have the load reports as an automatic by-product.

(SLIDE) Here is a typical room use report of Seattle, roughly about a third of the classrooms to be forgotten about at Seattle. Two-thirds were used -- the utilization was too high -- class-size and room size were almost too exacting. The impact, however, has been one in which they are now operating on this schedule at Seattle.

FORD: Thank you. I think it's valuable to have such a detailed presentation of one system. I imagine there'll be some questions here directed to the specific aspects of this system and how it works. I hope we'll also generalize our discussion to the advantages and disadvantages of such a system, and consider perhaps some administrative aspects of computers that have not been touched on by Mr. Blakesley. I'll now open the floor for questions and comments. BRIGHT: What computer was used and what source language are the programs written in? BLAKESLEY: The programs were written in COBOL for the 7094. LICKLIDER: What constraints upon professorial entrepreneurship are implied in this system? This seems to give the management awfully good knowledge about what the professors are doing. BLAKESLEY: Let's save the answer to that one for later. RIESER: I'd like to ask about the implications of this to professors and students. How do they look at this whole endeavor, how can the relationship enhance so that it doesn't end up to be one of the controversial problems that are well known within colleges? FELDMAN: Would it be possible to get some comparisons on several dimentions of the Purdue system and the MIT system? One of the principal differences is that the MIT system is, at least, some parts of it such as the registration problem. I would be interested in comparison between a batch system and a real-time system. GRUBB: In terms of a real-time system, I think it might be interesting to explore the implications for automated instruction, no matter what form that it's in. Where you are striving toward individualizing a great part of education for the student? What modifications would have to be made in such a program as this? How often would it have to be run to schedule students that would be taking courses perhaps on a demand basis, taken at a computer terminal or in some other form? MITZEL: I'd like some discussion of where room utilization collides with educational philosophy. Sometimes professors stay after class to talk to students in the same room. If that room is scheduled for the next class very tightly, he may be unhappy. LAMBE: I'd like to propose we discuss the extension of some of the things Mr. Blakesley has talked about to some continuous monitoring of exams and grade-point scoring. KOPSTEIN: Within this total administrative system I have not yet seen any provision for ascertaining how well the student is progressing and letting him know whether he is progressing as he should or whether he is performing below expectations, either in terms of absolute standards or the kind of promise he showed during entrance examinations. ATKINSON: This is really an interesting system for possible research. It might be worthwhile to start putting in some personality measures and prescore tests, and actually play around with the possibility of assigning the class via other information of this sort to see if you could have a grading system that might be of some value. Are you thinking along those lines? STARKWEATHER: I wonder if any elements of the output act as feedback to departments and divisions to the extent that they have effect on the planning of their curriculum in their particular area. BARRUTIA: What determinations have been made or can be made via this system of which students should have the privilege of registering before sections close. After certain sections are closed in the computer, how can we determine which students should be relegated to that backhand? LAMBE: To what extent in this system and others are there built-in alarms against curricular violations of a particular kind, that is, taking courses without prerequisites and that kind of thing? FORD: What are the defects of such a system? What are the things that, no matter how elaborate it is, it can't do? GERARD: I'd like to generalize several of the points that have been raised, and I hope that Mr. Blakesley or others in the room will be able to pick them up. I would like to hear more comparative discussion of alternate experiences happening around the country. Secondly, I would like to hear about any concrete outcomes beyond those that you did mention, some of which were impressive, as to an influence of such information on administrative decisions and actual procedures in the university situation. Have multiple reports been eliminated as a result of getting all the information needed, letting the computer do the calculations for particular purposes? And the comparable situation on space utilization availability: how much less building is necessary to accommodate a given number of students under what conditions? For example, there's one statement in the National Academy of Sciences Committee on Computers and Education Report that merely saving 2% in the utilization of rooms at the university and college level in this country would save a hundred million dollars a year in building. Now is this the kind of outcome that is occurring? Thirdly, I hope you or others will give us some input as to the total integration of administrative information. When you get data about a student, faculty, space, funds, equipment, inventory and all these things, how far has anyone gone in putting these all into a total computer information bank and having programs available that will enable you to ask the kind of meaningful question that would inevitably come up from time to time? And, finally, one specific point that came to me from one of your slides: are any of these data being utilized? Has anyone thought of utilizing them in getting at this extremely important problem of teacher evaluation? We all agree that if one could get better methods of evaluating teaching excellence it would upgrade the teaching function of universities. This approach may conceivably lend itself to that, I hope, that might come up for consideration. LICKLIDER: There's one particular point that Dr. Gerard just said that I'd like to have developed a bit. Most of what you presented has to do with forms that are sent from the computer to an administrator or a manager. The other approach is to let him ask questions, and I think there has to be some kind of a balance between the two. GRUBB: I'd like to further elaborate what would be needed in the data bank. I don't think we've touched very much on what predictive qualities might be built into the system. Several obvious ones suggest themselves, such as the percentage increase in enrollment by classes, space utilization, and so forth, so that the obvious ones are what one needs by year X in terms of space, staff, and so forth. It might be of interest to find out what other parameters would be needed in a model to offer some predictive quality. MILLER: Is it inherently impossible to operate on an on-line time-sharing basis in a student registration process? In order to be fair, to the last student that comes out of the computer, must you have a deadline up to which time you simply collect data, so that if students stop by a local terminal and put in the data they couldn't get immediate returns until that deadline? Or is it possible by some form of stochastic programming to give students immediate returns at the registration as to the classes they can take? LAMBE: There is a problem which seems very important to me, but which does not fall within the frameworks we are discussing at present, namely, the general administrative problems created by the large-scale use of computers.

FORD: Ed Lambe and I have put down six categories on the board which we think more or less encompass questions that were asked this morning, and perhaps we could use that as a framework for the discussion during the remainder of the morning. (1) Resource Optimization - Other Systems - Savings (2) Technical Aspects (3) Academic Measures (4) Academic Impact (5) Teacher Evaluation (6) Problems Created by Computer Use

Resource optimization was, of course, the principal subject of Mr. Blakesley's presentation. One question was asked which in terms of comparison of the Purdue system with other similar systems that may be in use in other parts of the country, and a question was raised on savings of space and money. By the technical aspects we refer, for example, to the question about the suitability of remote time-sharing consoles, through which faculty and administrators query the computer and get out information when they need it. There is the general problem of a large time-sharing system in which this type of administrative work is being shared with teaching and research usage of computers, and also, perhaps, techniques of output of information to students. By our third category, academic measures, we refer to that group of questions concerned with enlarging the scope of the system to include more student evaluation. There was a question on personality tests possibly being incorporated in some way into the total system. Two questions dealt with what I have referred to as academic impact, the fourth subject here. One was the question of the impact of such a system on faculty entrepreneurship; another was the question about the interaction of this system with CAI. And finally, a question was raised about the possible utilization of such a general administrative system for teacher evaluation. Time permitting, we might finally get to some problems created by the use of computers there. DAVIES: In connection with the first topic, resource optimization, it might be interesting to consider computer modeling alternatives, course of action, from the point of view of maximizing return of investment, in relation to building additional plants or any other administrative decisions. In fact, you might even have your department of industrial administration use this as a research topic and have theses written in this area. FORD: Mr. Blakesley, do you want to comment on whatever evidence you have about the positive advantages that flow from the system? BLAKESLEY: Let me digress just a little bit to a comparison with other schools. At Pennsylvania State, there is a tremendous program in terms of the admission of students. This is getting the student information into this core and its memory bank. Rutgers is just starting their program on scheduling. Their problem is a unique one, with the campus being on opposite sides of the river, and spread up and down from the girls' school all the way up to the north and the science area, and with 20 minute breaks between classes so that the students can travel. You have the problem here of trying a transportation model in addition to everything else. Their schedule is one in which they force the distribution of students by having a class Monday at 9:00, and Friday at 4:00. Here they're trying to get distribution and keep people on campus in a practical sense. Washington State is using a modified program of a demonstration given at the Western Data Processing Center in 1960 that went through the University of Massachusetts. The Washington State program varies the input; ours is a card pulling one, and theirs is a mark sense device, and they did not go to advance registration. So, Jim Miller, in part, this is an answer to your question, is it on-line or not? They proceeded to do this all in just the day or week before classes. They gave an audit routine where the department heads were there to make adjustments. They proceeded to increase the number of certain sections, decrease others, cancel certain courses, and then reschedule the students. So this is a device where advance registration was not required and one in which there was an immediate impact of the students coming in to be handled just before classes began. The University of South Carolina has our program and has modified it. They experienced the troubles that we did when they tried only freshmen students last fall, and found that they had a problem of running two operations, one on the computer and one manually. They had to divide classes, which presented a problem, and they are now shifting gears. They're not going to do anything second semester - they're going to wait until this coming fall and do the entire university. At MIT the assignment phase is, I think, very similar to Purdue's - at least Bob Holes and I are working very closely together, and have compared signals. The program there is somewhat more restrictive - our freshman students will choose from over a hundred different courses and at MIT there is no vet medicine course. The PASS program has been used successfully in high schools. As to which one is best, I don't know. I think the competition has been good. It's one in which we feel that we can come closer to a better schedule, but we've never tried it on the same school, so this is just to make an assumption on my part. And Bob Holes has done a tremendous amount of work along this line.

In terms of problems of implementation, there have been numerous ones. This is a matter of just getting down to telling people what you're doing and having them understand it. The lack of understanding has been a major reason. For example, the University of New Hampshire, I think, had headlines in the paper, when their students were up in arms because they were going to be assigned to classes on a computer. It was the same way in Washington. There was another instance where the archbishop of a Catholic college proceeded to get signatures of 500 students who said they weren't going to have this done. At the University of South Carolina, I spent most of my time sitting down with the editors of their newspaper explaining what would be done, the fact that they could have free time for this and that, and that the purpose was to optimize the use of resources. Surprisingly, they started classes with little difficulty. Washington State used the same technique with about three days of orientation session with the faculty, the students, with even the local community members being a part so that they became knowledgeable about it. I'm sure that there are many others. A number of site committees have been involved in the assignment phase. I think the University of Pittsburgh had a U.S. Office of Education sponsored mathematical model which is available, and Dr. Oakford at Stanford is doing research on the construction of an optimum schedule. All these efforts could be gathered together in one case and be tested and implemented on a common model. There are two research theses that have been produced, and a third one which is coming out of Purdue. One is

Gordon Sherman's optimum scheduling techniques which Professor Stan Reiter supervised. There is also my masters thesis. There's another one in computer sciences by George Morgan coming up. I think it takes this kind of interest in the academic area to develop these techniques that are useful for themselves. Where is my function in this? I think that our office serves the academic community. We may provide them with this opportunity and the job here is making sure that they know how to use it. If we do not do the job at Purdue, we are not going to be asked to do it, because we are an aid to accomplishing the task. At Purdue the only people responsible for the administration are the president, the vice president, the deans and heads of departments. I am not included in this. So if I don't perform this function, I will not be in operation. There's a good balance on the work that we do, and if the deans and the department heads feel that this is important we proceed. FORD: Do you have any quantitative measures of the extent to which resources are better used now than before the program came into effect? BLAKESLEY: I hate to say that the utilization of resources is the prime objective. If anything, I'd say that the real reason for all of this is the curricular flexibility of the student, and as a by-product you get utilization of staff space and time. If it doesn't serve this curricular requirement, I don't think we're serving the proper focal point. I know utilization can go up, we've tested it. You can double what is set up as national standards. The question is whether you're packing things in too tightly. Here's a philosophical point of view - how tightly do you want to pack? If you want that extra 15 minutes this can be programmed right into the classroom assignments. At Pennsylvania State, you had it with a 20 minute class break, so it's implied right in the system. We just don't know about staff utilization. My feeling is that the staff members' time for research is probably being hindered by the manually built schedule, and I would like to try getting the staff member's time so that he has blocks of hours instead of being disrupted by an academic schedule which nobody knows whether it's good or bad. It's never been tested. The current price of a square foot of classroom space is $60 on the net square foot space at Purdue.

Five years ago, we had 280 classrooms, we're down to 230 now so we converted 50 classrooms at the equivalent cost of $25,000. It's the same way with laboratories in terms of not designing new facilities, and we are going to concentrate these monies, whatever may be available, in the areas in which we lack additional research and office space. There has been a tremendous impact in higher education - 20 years ago the president's office was at home. Then we started the philosophy that we would provide an office, and then there were two-man offices. Now our whole objective is to get the staff members into an environment that he can do very productive work and research in terms of the office areas themselves.

FORD: Both your comments and several of the questions which were asked made clear that there are many aspects to this kind of system other than the optimization of resources, and most of the rest of the topics on our list are in that category. Before we go on to those are there any more comments? LAMBE: I'd like to ask if you know of any experiments or any tests to do some computer scheduling of this kind for courses which might be produced in one place and used by other institutions. Such a question might arise, for example, in closed circuit TV broadcasts to other units in the state. BLAKESLEY: I know of some of this. MATP - Midwest Airborne Television Program, is one. They are involved with very complex problems. One, they're in a five-state region: school systems start in different time zones, the lunch period is at different times, and now they're broadcasting on only one channel, and therefore are fixing, in terms of the total educational system that is involved here, the fact that Spanish is only going to be broadcast at 8:00 or at 9:00. This impact is quite serious on a program, and this is the reason MATP went to the FCC and tried to get three or four channels, so they could create flexibility. I'm giving you part of an answer, it may or may not be complete. Computer-assisted instruction in television at Purdue in a large lecture is the same thing as television class. There's a impass here. Televisions are large lecture classes singular at time or core-dated by rooms of instruction for an institution, where everybody meets at one time. It's one of the most expensive things that you can have in any institution because the rest of the resources of the institution stand idle. We've divided core-dates so that we have multiple periods. In television, we argue with the TV director to make sure that he broadcasts at least twice. This increases his costs, but it also increases the students' course electivity. I would assume that this would be an impasse all the way along the line where you have computer-aided instruction. If you were broadcasting only one thing at one time then channels could be used only in this way. There is no difficulty with the scheme of having the console itself scheduled just as a classroom. We're scheduling the aircraft for pilot instruction with the computer. It's just another one of these resources: it's a room, it's a computer, it's an aircraft, it's an environment for the learning opportunity, so this is implied in the CUSS program. ATKINSON: I think it might be fairly far away, but how about developing some preference patterns on students and faculty where you list preferences for course work during the week and have students select, from various patterns of class arrangements, those that they seem to think were most desirable and rate those at registration time? BLAKESLEY: We need to do work in this area. This is our first attempt, one which has taken a lot of time. We've asked the staff members, "When do you want to teach?" Some of them say, "I only want to teach on Monday, Wednesday, and Friday." We try to accommodate them. Others say, "We don't want our classes back to back, separate them at least by an hour, it's too much to talk one hour after another." Then there is this conflict between offering of the courses so you get an equal amount of instruction in the day, and the normal tendency on the student who wants to concentrate everything on Monday, Wednesday, and Friday. Then when there are exams he complains because he has five exams on a day. These are all intrinsic in a system; you do one thing and it's a penalty to something else.

KOPSTEIN: In listening to the description of the system, I can see this as being a great use to administration. It certainly allows the approach to an optimization of resources. But the question I'd like to raise, which I haven't heard yet in this entire description of optimization of resources, is optimization for what. I happen to have an understandable bias in thinking that the purpose of a university or any educational endeavor is to endow a student or students with certain behavioral capabilities, and this is the ultimate raison d'etre of the schools. Now I'm not sure but what any system that ignores this notion might be led to optimize along dimensions that aren't primarily relevant and might negatively affect what I think ought to be the primary purpose of an educational institution. BLAKESLEY: I'd say that under the manual scheme you do not know the influences on the system at all, so you can't control it, where as with this particular technique, unless it's down in black and white and is a part of the system,it gets ignored. Therefore, everything that's applicable can be looked at in the cold light of day. For example, intuitively you might say that professor X has been given time free, but now you'd have to say why the time has been given free. Intuitively, courses can be in direct conflict even though there are a hundred students that need them under the manual scheme, and there is no reflection back out of the system at all of the fact that they can't get them. This will come out as a by-product of the fact that these courses are required. I think that it depends upon how the people use this. If someone wants to abuse the system, I think he should be criticized. If he wants to use it to an effective means, this would be the key person. I think they should be under the control of the academic areas along with the administration. LICKLIDER: This comment and question is not to challenge the research, or that the important thing is to give the students and the faculty flexibility, it's to explore another facet. Things that are measurable readily have more than their share of impact. Before we leave the subject, I think we ought to have the measure of the simplest thing here that's going to have a very big impact in administrative and perhaps legislative thinking. Can you say what the advantage in dollars is? You gave a hint when you said it saved 50 classrooms. But if this could be put in terms of dollars of saving, where you say anything about flexibility for students and faculty, it's just gravy, but we didn't really save so much educational expense in return for spending so much money. BLAKESLEY: I'd say we increased by 30% the use of classrooms and laboratories without any difficulty. Normative data was collected saying how people use facilities. This normative data now has been used as a means for forecasting what is needed in the future. Nobody tested the thesis of how well one could use these facilities and used that as a design criteria for building. And to this example, if you have volume you should be able to get high use. If you don't have volume, I would defend the university and the colleges for low-use facilities where it's a specific program. Now these averages tend to bring things down, but what's happening right now in high use areas is that they're going ahead and building on the fact of only 20 hours of use. This is what we're doing. We're attempting to find where the volume exists, then utilize the technique that we have for high use, then take that money and use it in an equitable fashion in the areas where we lack facilities. We're still short. The problem is that we can't even buy buildings, and we have to plan five years in advance, and this technique is a mechanism for estimating what we need 10 or 20 years in advance. You may recall that I asked the question of what CAI is going to do in terms of the facilities, four to five times the area is one thing that will have an impact. It will be quite a big laboratory. GERARD: Just one very concrete point in answer to Licklider. Blakesley, you said there had been a 30% savings in space utilization. The National Academy of Sciences Committee on Computer and Education report which I referred to earlier says that there have been claims of 15% savings, but that they are very skeptical of those, and the only thing they are sure of has been demonstrated as a 2% savings. If you can document your statement it would be very helpful. BLAKESLEY: I think that both are correct. Number one, you're only getting a savings in classrooms and laboratories, and what have we on the board was only 15% of the total space. So the 2% probably holds true. You're not going to get higher utilization of offices. You're not going to get higher utilization of research facilities, but we're now looking at how to schedule the student and research so that you can use these facilities maximumally. How do you program the student through his graduate courses? And to include research so that you have a chemistry research facility available. This is more of a linear measure than the simultaneous problem of starting classes all at one time and have them organized. LICKLIDER: I can't resist challenging your statement about the use of offices, even if this is only a whimsy. You know about movable partitions. Now think about movable partitions under computer control, so that when a man happens out of town or on leave, his office shrinks to just the space that contains the furniture! BLAKESLEY: Or when you get the raise in rank it grows! FORD: One way to look at the system you described is that it is an enormous bank of useful information. Some of the questions that were raised had to do with how to extract that information for more benefit than is now done. The main flow is now to administrators, but faculty and students are also interested in this. Counselors were concerned with this problem. and with getting more information out for more useful purposes and also for putting more information in and enlarging the whole system or extending its purposes. I'd like to go onto those topics unless any of the previously raised hands still want to get in on topic number one. One question was raised about the technical aspects was the suitability of time-sharing, remote console access to this information, by counselors, faculty members, advisors, or what have you. Any comments on that? LAMBE: I have a question that I wanted to ask, namely, is there any work at Purdue on using the computer for some current fiscal purposes, departmental budgets, rate of expenditure, solving the ordinary problems of decisions of departments which in some cases could be enormously easier? BLAKESLEY: We're studying the next generation of computers now with this off-line capability. The computers are used in administrative financial matters. One of the problems has been the undesirable characteristic of people always wanting their own computer and not sharing it. Typical of this is the accounting office that wants to get quarterly reports, or annual reports, but the Data Processing Center on the 1401 feels that there's too much time sorting. Therefore, they can't do it because the payrolls go ahead. But here's the 7094 that sits idle on Saturday afternoon, let's say, where they could take that whole tape file there and sort it down and proceed to give the accounting department what they wanted. We ought to be using this large computer tied in to the point that they could get these management reports the people are waiting for now and having to review, individually summarize down to the point that they're more useful. I don't believe I can criticize them other than the fact that maybe there's not enough resources there again to program this and get it into a model that is more useful. Everybody budgets his time and payrolls need to get out or everybody will complain. On the on-line versus sequential method of scheduling students, you're always going to have to have the doors open. I don't believe that you want to refuse somebody who walks in on the first day of classes because the class is closed. The concept would be that you construct a master schedule using CUSS or GAS, and you have this environment and continually monitor it to see if you are in control, if sections are filling that you anticipate and, if they are not, you're alerted on some management scheme. But it's the same thing on the track of each section or each course, whether enrollment forecasts are accurate. This is the concept if we could ever get it in we would know where we are to our best guess. Then after the schedule is there we wait until the first day of classes and we reschedule everybody to optimize, which requires only an hour. The problem is how to advise the student that his class has been changed and he should take another schedule? Or do you forget about this and give a mass distribution of schedules at that particular time? The terminal idea that Irvine is using is for their students to type in their course requests. KEARNS: I don't think it's planned to have the student type that in, but to have a secretary or a typist at the console. BLAKESLEY: Like Indiana University? KEARNS: Eventually. BLAKESLEY: And will it be to section or to course? KEARNS: Well, it will merely be the schedule for the day. BLAKESLEY: OK, you're getting the course information. KEARNS: After they see the faculty advisor. BLAKESLEY: After they see the faculty advisor, and then there is an audit routine which will give you the number of students involved in each of the courses. You can make the judgment factor using something similar to CUSS going ahead and constructing a master schedule and distributing the schedules to each individual student. Your only problem is fee assessment and getting that in before the person shows up for class. FORD: I think the general philosophy that is planned for Irvine is to make available at the terminal as many and as much of all the operating systems in the computer as is possible.

MILLER: I asked if whether it might be possible to give the first student who comes his schedule back immediately and every student thereafter, and yet on a probabilistic basis make it equally fair to the last student that comes in on the day that classes begin. This would mean a continuous calculation of the probabilities of each section filling up. But if you have an on-line facility, it's most efficient, isn't it? The student gets his course assignment back at the time that he's at the console. Perhaps you could motivate him to do it early by increasing the probability of his getting into a section somewhat, just as a motivational factor, but it should be possible to calculate it so that he would have the same possibility even up until the day that his classes begin. BLAKESLEY: I think this is being done in a way because we're processing it sequentially by students now. The University of Illinois has a factor which gives the student section assignment, but they have a little program in there so that when enrollment gets 70% of class size, the program starts telling people that it's closed, you're going to have to be rescheduled, so they give them some priority on sections. The only problem that I see is the speed with which they can get this information back out. If you have 20,000 students and each one is at a terminal and asks for this, and you have to have it typewritten out instead of on a high-speed printer, you may get a problem of just the amount of time that the console is tied up for this particular function. KEARNS: I have just one point on that, and that is the fact you're assuming that you're going to do this with the 20,000 students all registering or enrolling on the same day. During the preregistration period while they're seeing their faculty advisors this is spread out a bit. SELFRIDGE: I think the question of serving students on-line is not as important as serving management on-line. If I were any one of your administrative officers and you gave me this incredible flood of numbers, which you showed in slides, I'm sure I wouldn't read any of them. I'm not quite sure what my reaction would be to having a part in that. Surely, to make this on-line available to the management people so that they could ask it the questions they wanted and feel that they could get an answer quickly, that's where the value occurs. BLAKESLEY: Currently, what's happening is that the information you see here is my best guess of what they're going to ask me, and very little of this goes in to the administration except in summary reports that are a page long. In other words, I want to try to anticipate right now the fact that someone is going to call and say, "Now what do we do next year when we hire 200 additional staff persons, where do we put them?" This is the kind of thing. Other questions are:"Can we increase our enrollment by 2,000 next year, do we have enough classrooms and laboratories? Where shall I put the special project money so that I can optimize the use of these funds to make sure that we can handle these students?" We were surprised that each year we have been able to do a little more in terms of the use of resources in the plant.

MILLER: What is too high a use? BLAKESLEY: I don't know. We thought that we were going to be at a capacity of 30 hours on the average, and then we got to 33, then we got to 36, and even in one of the faculty Senate meetings when we were going to the 54 hour week, one of the professors in English got up and said, "Well, I still find classrooms that are free in the afternoon - why can't we use those and build more offices?" And this is what we should be doing if it's free. MILLER: Do they get in each other's way as they're going out of class? BLAKESLEY: No, because if you go to a building at any one hour, whether it's between 9 and 10 in the morning or 2 and 4 in the afternoon, it doesn't make any difference. We had to shift all of our physical plant janitorial staff into the evening, which is after 10:00, so cleanup is a nighttime operation. And there is a disadvantage. We've found that in the classroom areas, unless we come up with a better device, you've got 10 hours of chalkboard dust and everything else on the chalkboard and no cleaning done between the beginning and ending periods. LICKLIDER: But not a very great disadvantage. BLAKESLEY: Depends upon the professors - we had one that picked up a pail of hot water and walked in just before his class, since the janitor wouldn't do it. MILLER: Get disposable blackboards! GERARD: Selfridge's question about getting the kind of information to the people that they want in contradistinction to what the computer has been prescheduled to give out on somebody else's guess as to what the person will want seems to me exactly the problem of the structure of the file that Licklider brought up yesterday. I wonder if you have any comments on that, Lick? Or if anybody else wants to comment on how one can fill all these things into the data bank and, without an impossible amount of preprogramming, make it available for different kinds of questions across the grain of the input structure. LICKLIDER: There are so many examples. The MITRE Corporation has worked on a system called ADAM (Advanced Data Management), and a system called AESOP, a system in which there is query language that is not very complicated. Military people master it quickly and can ask quite complicated questions of the data bank. They find that the most important thing is to combine control of information processing through the query language - processing designed by the query - with information retrieval. It just isn't good enough to retrieve information because there's always too much of it, you want some way to sharpen your query. What they and other organizations have done is, I think, directly applicable to this problem. I don't see any technical difficulty beyond getting the administration of the university to appreciate what range of questions it can ask, and then handling the mechanical problems that arise because most of the administrators either don't type very well, or don't want to type so there is need for some link. I think in terms of a new kind of secretary who is also something of a computer buff and who will be an intermediate between her boss and the computer. Incidentally, I think that opens up an intellectually challenging work for young ladies who get bored just hitting the keys of the typewriter. STARKWEATHER: Yesterday, Lick, you mentioned something just in passing which you described as adaptive, a dynamic reorganization of filing for the scheme of the data base in response to the line of inquiry that people took and the history of such inquiries. Are there any things that you know of in which this idea has been implemented? LICKLIDER: I think there is some dynamic relocation in the system of MITRE to which I referred, but certainly almost everybody in the field of management information systems or military information systems is working on file restructuring or reorganization of the dynamic storage. And the picture that you have in mind is simply that there is a hierarchy of storage, and in general the smaller stores are rapidly accessible and processable and the larger stores cost less and take a longer time to get to. So there is a slow but continual flow of information up and down the line. Information is likely to be used on the basis of predictions based on experience of moving toward the accessible end, and information that hasn't been consulted in a long time or which can't be figured out from schedules that keep coming up, and you know when it gets to be the first of September that means a lot of information about class scheduling that hasn't been active should become active. So either on the basis of use, records or schedules in this state of use, these things can come into a place where they're easy to get at, and it's going to be kind of complicated to handle, but it's easy enough to put all of these things off onto the systems programmer whose duties are to know how to make it work. FORD: I'd like to insert a practical technical problem. There seems to have been a very definite trend in the last few years, toward where the best computer service on a campus is provided by one single central computer which serves all of the functions of research, administration, and teaching use. I'd like to find out if anybody here holds a contrary view and feels that there are advantages from separate facilities. STARKWEATHER: Isn't it the case again of the short-term capability against the potential long-term benefits? In some instances, a tremendous system would have to be built in order to make possible operation over the combined enterprise. I'm thinking of the campus that I'm on, for example, where we have room to build a system for hospital administration, which in itself is rather complex and will lead toward a hospital information system and its operation. And there is the need, on the other hand, for research of capability and perhaps teaching capability, too. I think the short-run view is to make the thing work in the next year, or at least run it separately now. I don't know whether you can build systems under those conditions which still make it possible to move toward the integrated thing you'd like because obviously some of the research enterprise might like a kind of file organization that possible administration might end up with, but not necessarily, and there is an overlap that one can clearly see that you would like to have eventually. But I think again it's a short-term need to manage at all. That you have to recognize and balance off. SAUNDERS: Well, I think that the small departmental computer versus the large central computer is one that I used to think had a great deal of merit. I have abandoned that. I justified the position on the basis of the pedagogical value of a student being able actually to feel that he was conversing with the computer, and I was inclined to place the cards in the hopper or send them by messenger for batch processing in a large, central facility. I abandoned this position when it became quite apparent that time-sharing was coming into the picture. Time-sharing from a pedagogical viewpoint gives the student a sense of being on the computer right now, and you can get around the psychological issue that he's working with an impersonal object that he never sees. KEARNS: One of the questions that was asked was whether you have the terminal capability for administrators getting the reports that they want. There is a query language storage and retrieval system that's going to be installed in the university at the beginning of next year - it's already been discussed with a number of universities - which would give the ability to the administrator of getting the types of reports that he wants at a console, whether it be a cathode ray tube or some other type of console. It can also give him some sort of capability of a very simple language of stating what sort of manipulations, arithmetic or otherwise, he wants to perform on the data. It's not a question so much, I think, of separate facilities, it might be a question of a network of computers. BRIGHT: I have two comments. I'd like to distinguish a little between separate computers and satellite computers. In these large complexes you may have satellites next to the big machines to relieve some of the input-output requirements. There's no requirement that satellites need be next to the big machine. Secondly, from the industry point of view, for about two years we have been running a time-shared computing center as a research laboratory where we have various priorities. We have programs with running times less than two minutes where the person wants it immediately. We have the next one as large as five minutes run time if he wants it immediately, or a bit longer, and then we have ones where they don't care whether they don't get it back until tommorow, and so on. Each one interrupts the ones with higher priority, have dynamic memory allocation, so that if you call for a magnetic tape or something off a disc, while the machine is sitting waiting for that it will be running for the next lower programs, and so on, ought to be running five or six programs in core simultaneously. Here we are offering turn around time of approximately one minute more than the run time of the program in the production phases. Now we do have remote typewriters. I am sure not inclined to pay $1,500 a month for engineers to sit there and bang at the typewriter, it just doesn't make any economic sense at all. There are a few cases where people are closely interacting with a computer and trying to see what happens with a simulation - it probably makes sense. But for ordinary problems it certainly does not. Essentially, what we do is to, say, eventually write their problems in ALGOL or whatever other languages they are using, and the standard keypunch operator will punch these out and they will be put on the machine intact. The man can then look over the thing and if he wants to punch one of two additional cards himself and shove it back in again, he can. It's not at all unusual for an engineer to give five or six turnarounds in 15 minutes - he's looking over things to make it correct and putting them in. SELFRIDGE: I don't think you understand time-sharing - and your system is not a time-sharing system at all. BRIGHT: I quite understand time-sharing. SELFRIDGE: Well, I don't think this the time or place to go into it. BRIGHT: What I'm saying is that it does not make economic sense to turn the high-paid engineer into a typist. SELFRIDGE: You talk about him as a pencil pusher. You say he writes his programs using a pencil. Well, there's not much difference. Some people type much faster than they can write, as a matter of fact most of us here do, as I said I don't think we have the time to go into it but I'll gently deplore the statement. FORD: I think we ought to move on to topics three and four. These are concerned with the academic aspects of the large administrative use of computers. That includes, first of all, the category of topics concerned with enlarging the type of program Mr. Blakesley described for even more elaborate purposes. Another important question in that general category was the interaction of CAI to this type of scheduling, and use of computers. SAUNDERS: I had my hand raised before when we were talking about topic number one. I wanted to differentiate here between the optimization aspects of scheduling and the information flow to the administrators, and I am rather pessimistic about the optimization aspects, because I think the criterion on executive functions are different with different people. The student has one objective function, the administrator has another, the legislature has still a third. They're not entirely compatible. The only thing that you might say they have in common is that they're maximizing happiness, which we can't seem to measure, and what is happiness for the legislature is not necessarily happiness for the student. I'm convinced that at this stage of development, we maximize the happiness of the students by letting them do their own optimization. Each student does seemingly have different objective functions, and we might be able to maximize the happiness of the legislature and of the administration, but at the same time minimize the happiness of the student and thereby have a real problem on our hands. GOODMAN: I've detected here two strands, two very different points emerging. One is the idea that it is possible to build schedules and make reports more valid by use of computers. The second one, which is separate, whether it is possible to allocate resources and set priorities in ways other than those we have in the past. For example, my associate dean right now asks me whether I want to teach. If he told me when I was to teach and made the schedule up by hand, I'm sure he could probably find better utilization of space and better allocation of courses, more elections for students and so forth because that's what's dear to him. On the other hand, he could still ask me what I wanted to teach and use the computer-aided scheduling program and improve on both counts as well. So these are two quite different things. Now they merge when he recognizes, as we all do I think, that the minute you try to computerize anything you pay attention to priorities in a way that you never did before. And it's very likely that this is one of the reasons that you have such a negative impact on so many people when you talk to them about computers, because you've forced upon them challenges to their priority scheme in ways that they think have something to do with computerization but which actually are just a challenge to their intuitive value systems that they hadn't questioned before. I think these two things have to be kept straight. You could say, "Well, what do we save?" Well, how much do you save by computerization on the one hand, and how much do you save by reallocating your resources on the ----, I'm not sure that these can be kept separate. BLAKESLEY: I think they may be in the simulation capabilities whereas in a manual schedule you build it only once and certainly this avenue of approach of seeing what influence it has may reject maybe a hundred students because you and another professor may want the same hour. It may be that your requests could be satisfied and have no influence on the schedule, and with the interation time of maybe only an hour for an institution of 5,000 it should be answered this way.

Surprisingly, one of the difficulties was this need for the intuition to be recorded. We found this in gathering the data. The individual put down one thing, the department head changed it, and the dean changed that, and on the last go around when it looked like they were going to be 30% over the budget, the vice president changed everything. And it was just a matter that the individual staff member wanted to reduce his load in terms of class size and hours and more free time, and when you did this you had a triple impact upon the economics, but you had to go through the exercise to understand it. So if you have anything in the system you now have a management game in higher education which should be pursued. LAMBE: Last night Dick Atkinson threw out a statement which raised a storming response. Let's see if I can play that role. I'd like to suggest very strongly, that the most important thing that computers could do for the educational system as a whole would be in some way to break the lock-step which we are currently engaged in which is primarily forced upon us by a secretarial necessity. If one thinks about doing that then it's not too difficult to believe that one could perhaps break the whole course structure into much smaller units and provide in some presumably computer-assisted way, tests and measures which are progressive in some way and which can be continuously recorded, not only recorded at specific times like February 1 and June 1. I would like then just to raise this whole question of how one goes about developing a unit system where the units may be of the order of lecture hours and having those recorded in a student progress file, and what kind of opportunities this gives us for handling a student's curricular problems. FORD: I'm waiting for a reaction. MILLER: Well, the silence is obvious, it's so dramatic a suggestion that you make, you're going to change an entire student's curriculum directly over to the computerized curriculum. Of course, this gives you an opportunity to combine programmed instruction or television techniques with direct access to the students into the prerequisite system. It's something that certainly couldn't be done by any ordinary secretarial methods that we have at the present time. If you were to find the student part way through an ordinary course is weak in certain areas, you could program time for him to go into these other types of activities. I would support that what you would want to do is to get a really effective dynamic system operating like the one that we've been hearing about this morning, which operates in terms of the ordinarily sized units which are courses, then breaks them down into fractions, which might eventually get down as small as a given hour or a given week-unit of the course, and then it begins to substitute other needs in terms of the individual needs of the students. There's nothing to prevent individual professors from doing this but controlling the course unit at the present time. It would seem to be the way to go about it, given that's the way all universities operate at the moment. If we get the individual professor to recognize the different alternatives he has for utilization of the time of the students within his course, and get a number of examples of this sort of thing operating within the course unit, then perhaps on a university-wide basis one can begin to break into these smaller units. Not that I don't think your idea is fundamentally desirable, but I wouldn't suggest you go about this practically by immediately breaking courses down into smaller units until you have some examples like this actually operating. CORRIGAN: In reference to the use of the computer to break the lock-step, actually in essence this would require a restructuring of the whole organization of the college or university and the facilities themselves and how they're constructed. For instance, Sam Polsterwaite at Purdue University, is providing a model of a completely self-directed learner-oriented approach in which the student spends four-fifths of his time in a carrel. That model of learning in which a student spends four-fifths of his time directing his own learning progress has been implemented at a college which is designed specifically to minimize facility requirements, in the sense of multiple student positions and a minimal amount of administration and offices, and actually doing away with the classical laboratory setting which is very, very inefficient, integrating laboratory experiences right with what is called the audio-tutorial method of instruction. These kinds of rearrangements of the facilities, and redesign, have resulted in very marked savings in dollar commitments for college facilities in terms of the number of students to be handled, yet meeting Mr. Lambe's requirement of lock-step. Individuals are proceeding with scheduling their own time, arriving at a carrel, and where these carrels are open 14 hours a day for students to proceed to reach certain prime objectives against course elements.

At the community college in Union Lake, Michigan,they are planning to form in steps or milestones designed against a whole set of learning or structural advance. They have provided tutors who are available to assist the students and are very much a part of the instructional staff, professors down through the classical assistant who is tutor. The actual group assembly procedures are used periodically but are in support of the committee self-directed approach. Now in the present configuration there are some 600 carrel postions accommodating some 3,000 students with as much as 30% reduction in facility requirements. Dollar-wise there is a tremendous savings in physical dollar commitments.

In terms of Mr. Kopstein's question, "How is the college meeting its first objectives?" - that is, optimal learning or development of an individual behavior modification. This college is designed to compromise and to meet that first objective, compromise cost of facility commitment. It certainly meets Mr. Lambe's requirement of, "let's break the lock-step and identify it". Behind it all is the empirically designed process of determining what are the relative objectives of learning and designing courses toward this self-directed audio-tutorial application to provide for assured predictable learning. Here are some solutions that I think are in front of us, not X years away. It's operating now to some 4,000 students. In terms of its implications of computers and universities, the system is designed right now to integrate computers some two years away. They're in the process now of involving computer applications for administrative purposes, but eventually it's being integrated in as part of the whole computer system and classroom operation, where there would literally be terminals at the carrel sites which will also integrate with access on call by a student from a carrel in a centralized computer facility. So here is an operating model which gets at some of the parameters we are talking about, and it's operating right now for 5,000 students on two campuses which started in September. This community college is completely committed to this whole concept of a learner-oriented, self-directed approach, totally applicable to computerized application. So the real world requirements for taking a look at some of the potential, operating models, are here. And I think of equal significance is the system's management model under which the college operates. It is involved in the design of instructional systems and a validation of those - mainly, will these systems or courses of study do what they were designed to do, namely produce the kind of behavioral modification we're interested in? They're under a continual process of revision until they do achieve these stated objectives, so that the actual management itself is divided into a group whose function is to design the systems and an administrative function which will accept the system and implement and validate that. FORD: Well, I think our time is more than over. But it is the chairman's prerogative to make one final comment on Lambe's remarks. I think the important part of his remarks related to this morning's topic is whether the large administrative program for enrollment and scheduling makes it easier or harder for educational institutions to evolve and change their curricular pattern. Universities are highly conservative organizations and an important questions is the implementation of these enormously potential developments. Thank You.

- END -

Thursday, November 11, 1965

SESSION VI

Administration -

Top Level Information Flow

Chairman: Daniel G. Aldrich

Speaker: James G. Miller

GERARD: Lambe, would you give us a brief summary from the morning?

LAMBE: It seems to me that this morning we were looking particularly at some achievements that have been made already in the field of computer-assisted administration, and then we talked more about different new opportunities that one could foresee. Mr. Blakesley told us in some detail, and there was further discussion, about resource utilization particularly in the field of staff and space resources. There was some discussion of what possibilities existed in on-line service to management and on-line service to students in terms of information about these resources, scheduling, this kind of thing. The discussion then turned to academic measures that could in some way be assisted with computers. Questions of academic impact, the interesting question raised by Dean Gerard of what future evaluation might be possible with some computer systems and a problem that I've been very interested in, the question of what new difficulties come about when we do have computers so heavily involved in campus activities: These we didn't get to, and perhaps this afternoon there could be some attention paid to these.

GERARD: I did want to start the afternoon by reviewing that, and I will say, in case this encourages Jim Blakesley, that he had some interesting things to contribute on teacher evaluation.

ALDRICH: Thank you. I appreciate your starting the meeting off reviewing the principle ideas pursued this morning because in so doing, it brings to mind perhaps what should be the text of my comments for the next few minutes. The subject is "Top Level Information Flow" and the chairman is supposed to say something for a few minutes prior to turning the discussion over to those who had background to talk. I have very little of it, but inasmuch as I do fit into the picture of administration, it occurred to me that I might reveal my complete ignorance about the subject and simply indicate my concern as an administrator or at least as a responsible individual on a new campus. And in the revelation of my ignorance, hopefully this will prompt you to comment about those things you think an administrator ought to be mindful of, if he is concerned about the use of this science and technology involving computers in the building of a new campus. The thing that strikes me immediately as I read the topic "Top Level Information Flow" is that from where I sit on the campus, top level information flow is going to be just about as good as bottom level information flow, and that's my problem most of the time, being unable to get at the information. I don't say unable in the sense that people are withholding it, but in terms of reaching out at any point in time to get ahold of the information, that enables one to move forward with a decision arrived at either intuitively or on the basis of good information to support it, is a problem that constantly confronts one. And certainly here at Irvine, there is wrapped up in now two and a half years of experience, and six weeks of experience with students, all the ingredients that go into what I would say is a perfect case for determining how to involve computers or the idea of systems analysis in administering a campus; whether we're dealing with the student situation, with basic services, with housekeeping, with budgeting, with major capital outlay, the physical plant development, the library, the staff, faculty needs, instruction, research.

These are all ingredients that an administrator concerns himself with and to the extent that he feels that he has the resources in his colleagues, and has confidence in what they're doing and the decisions that they're making, he removes from his daily or nightly consideration a part of the load, because he is aware that the information gathering, retrieval, dissemination system at their command is functioning effectively. You have confidence in what they're doing, but that in turn is based upon or built upon the nature of their staff and works down ultimately to an individual, the student, staff or faculty member. In the few weeks that we have been involved at Irvine I know that on the one hand, I have people who are knowledgeable about the use of computers--they know something about information communication science, data storage, retrieval, dissemination, etc.; but there are a lot of us who don't know much about this, and we have the day-to-day job of keeping this enterprise going. Hopefully, at any point in time, sufficient light will strike us to know how to form a bridge between those who are knowledgeable and we begin to shift from our antiquated ways of doing business to something that is more expeditious, utilizing the information that you are knowledgeable in, but the fine fact of life is, day-to-day, you have to be working with students, faculty, and staff, and this involves time and energy and resources. So the marriage that takes place between the knowledgeable one in the communication and information science and the use of all the hardware that goes with it and the one who's plugging away in somewhat ancient fashion doesn't occur, and really, we have to build into our operation or accumulate for our operation, resources to parallel in each area an individual who's involved in the day-to-day business in perhaps antiquated fashion, with that individual who is free, time-wise, energy-wise, and thought-wise, to come together with the man who has the wherewithal to begin the modification of this whole process and the elaboration of the system, and in the new enterprise, very frankly, one of the problems is getting the resources to provide the individuals free to make this combination in time, in thought, and in energy. Little by little, we are proceeding, but from my vantage point, this is one of the great problems. At conference after conference, administrators often sit with knowhow such as is undoubtedly around this table, a man in the library, who wants very much to see things modified in the library, or in student affairs or in business affairs or in the business of setting up policies and procedures, rules and regulations, attitudes, etc, but they just don't get free to interact with that person. This is one of the practical facts of life, and if there are notions as to how one who is concerned about making this transition can get the resources to bring the appropriate people together, I'll be interested in them, among other things that you would have to say. And with that expression of great concern about what you can do to assist those concerned with top level information flow, I would turn to the catalyst for the afternoon, a man that will set the pitch for us and enable you to interact more appropriately, Dr. Miller.

MILLER: I think that it is a little peculiar for a psychiatrist like myself to talk about information science at all. I entered information science through the back door, but I have concluded that this is the only entrance to the field that is open. It is also a little peculiar that I, who am not in management of universities, should talk about top management, but perhaps I can add a little objectivity for that reason. I am reminded of the story of the lady and the minister who were in a DC3 which was being tossed around pretty vigorously in a thunderstorm. She became more and more frightened and finally she turned to the minister, recognizing his clerical collar, and said, "Can't you do something about this?" He said, "I'm sorry— I'm with sales, not with management!" That is my situation.

I want to thank Oliver Selfridge, Licklider, Bob Hayes, and Merrill Flood for contributions that they made in some informal discussions to some of the ideas that I am going to present. They are not responsible for any of my comments and will criticize them once I've made them, but I made a search of the literature and found almost nothing on the topic to be discussed here. I needed to get some information somewhere, so I got it from them, among other places.

Now what universities do primarily and first of all is to process information, and the role of the new technologies discussed here is to improve their processing of information. I think we can say that it is not perfect anywhere, even at Harvard. President Conant said some time ago that one reason there is so much knowledge at Harvard is that the freshmen bring so much in and the seniors take so little out. This is obviously an abnormality of information-processing in the university.

At all levels of systems—from cells to organisms to institutions like universities to societies—there are flows of matter and energy and flows of information. There must be subsystems or components which have their own boundaries and which carry out the various critical processes involved in these flows. In planning a university, some of your first thoughts must be in terms of inputs of matter and energy. You have to think about the sewage system. You have to think about how to bring in supplies and equipment and how to store them, how to distribute these various necessary forms of matter and energy throughout the campus, and so forth. After these fundamental logistics have been taken care of, the next thing you must think about is the information flows. There must be arrangements for information input—with the faculty, with books, with programmed instruction to the campus. There must be ways to make the decisions concerning this information which control all of the subsystems that make up the total system. This is the role of management. Finally, there must be ways to transmit the decisions throughout the whole organization so that they are coordinated, both internally and externally in the society. These are some of the things that I am going to talk about.

Recent technological developments show great promise for improving information processing systems. Some of these new technologies are:

1. Very large, fast computers which can operate hundreds of remote terminals in an on-line, time-sharing mode.

2. Very large electronic information storage units.

3. Telefacsimile machines which can transmit printed material, pictures, and diagrams quickly and cheaply, over an ordinary telephone line.

4. Photoreaders which can automatically transfer typed material into electronic storage at very high speeds. Photoreaders for printed material should be available within the next few years.

5. Carrels which contain an electric typewriter on-line to a computer, and a television screen, also attached to the computer, which can display printed pages, pictures, graphs, and so forth on request. The user can signal the computer by the typewriter and also by shining a light pencil on the TV screen.

6. Increasingly sophisticated computer programs, which can be used by people who do not know machine language, and which can manipulate electronically stored information in a variety or ways. Programs can be written to abstract and index, to translate from one language to another, to "read" electronically stored books and journals and print out parts of them in response to a wide range of questions; to inform users automatically of new publications; and so on. Centralized, automated library card catalogs, student record-keeping, budgeting, accounting, and many other administrative procedures which can be addressed from many remote terminals are now possible.

How can top management of a university benefit from these new technologies? New facilities, new procedures, and new ways of thinking will have to be developed before we can use these methods to the best advantage of the university, its faculty and students, and the community which it serves.

First of all, let me say that the system which I am going to describe does not now exist in any university, now do most aspects of it. I am talking about long-range possibilities rather than immediate possibilities.

First, I think that a necessary and important part of the university of the future will be an information center. This information center will probably be a single building in the center of the campus, intellectually if not physically. It will be a multimedia center, using books, television, microfilm, programmed instruction, and an on-line, time-sharing computer system. It will connect to national networks, which I shall describe more fully later, and it will be the center for a local network of remote consoles, carrels, and other such terminals throughout the campus and perhaps throughout the region or the community.

The planning of these information centers is, I think, a critical priority for government agencies. The prototypes which they subsidy would be proving grounds to find out to what extent such centers do improve higher education. Just as the year before the invention of the telephone, the average person could not see the impact of the telephone on his shopping habits, on his willingness to allow his parents to move to retirement areas, on the integrity of the family, and on many other things, so I think we cannot see the possible impact of these new procedures until we actually use them and have proving grounds where their values and costs are determined.

Combining all the different information processing media into one central facility will mean that many conventional ways of thinking will have to be changed. There will be resistance from a number of groups of information processers who traditionally think of themselves as independent and who very frequently do not communicate with each other within any given university. These are the librarians, the scholars, the researchers, the students, the administrators, the auditors, the physicians and patients at the university hospitals, and so on. There is likely to be conflict between information-processing in terms of books and information-processing in terms of computer technologies, and there is likely to be conflict between the academic and the administrative branches of the university. The old belief that if you want to control something you must own it yourself will have to be replaced by recognition of the advantages of joint sharing of large facilities. I do not think this will come about until, first, there have been many experiences with remote terminals; and second, the time-sharing procedures of the university are sufficiently fool-proof that the different groups are confident that a central facility can organize and carry out these activities capably and conveniently. After that point is reached, I do not think that there will be any conflict about centralizing any of these activities, but before then I think there will be some problem.

Second, this on-line, time-sharing community should be of the sort that Licklider described, which regards itself as a community and thinks about its own improvement. A certain proportion of the total activity, then, will be devoted inward upon the system itself, not only in terms of system programming but in terms of the goals and activities of the university as a whole.

The converse side of the notion of computer time-sharing by many different users is the notion of the multi-purpose, multi-media console. I think that just as we may be able to share one computer for many consoles, we may be able to share one console for many different media, and we should progress as rapidly as we can toward such technology. Also, since the same media will be used for multiple purposes, there is no reason why the same console should not be used for academic administration, for information storage and retrieval of a scholarly sort, and perhaps for patient care. A medical dean who handles all three functions could then do them all on his own console.

Third, the system must be active rather than passive. It must suggest documents which are relevant to topics being considered at the console. It should alert the administrator to new developments in the university which may be relevant to his activities, and should do so on its own initiative.

Fourth, there should be dynamic information readjustment and updating, so that an administrator can know that he receives today's data concerning student enrollment, or that the record of the student whom he is about to counsel is current and contains the student's latest grades as well as his physical examination report.

Fifth, there should be feedback from faculty, staff, and students so that the system is administratively productive. At the present time, administrators often do not get complaints and criticisms because there is no adequate and courteous channel whereby these can be obtained. I therefore suggest the inclusion of program GRIPE in the system. If the students or faculty are dissatisfied about the parking arrangements around a building, this information would be automatically put in; if adequate supplies are not available in one of the chemistry laboratories, this information would get to the right source, and so forth.

Sixth, there should be forgetting of some of the information, or as Licklider suggested, the placement of the information into a form of storage where you can write it in but never get it out again--which is the equivalent. A man's past should not hound him throughout life. One of the reasons the Russians do not use psychological tests, were were told when we visited the Soviet Union, is exactly this: that the Russians feel that test performance early in life should not, throughout your life, determine your entire future. Harvard refuses to release the grades of Presidents of the United States to the press for this sort of reason, and it seems to me that we should give some serious thought to the general fading of information of certain sorts out of the store over time.

Then there should be secrecy in the system. There should be secrecy for grades, for the keys to examinations, for patient records in university hospitals, for faculty evaluations, for references, for administrative decisions of various sorts, and there should be rules written out and incorporated into the system whereby the secrecy is maintained and protected. It may be extraordinarily difficult to write these rules--perhaps overly simple rules will be used at first. It is a consideration to which a good deal of thought should be given, and one which I shall mention in another context late on.

Seventh, the system should involve courtesy and frankness. The computer should be programmed to respond courteously with the appropriate "thank you's" and so on. Programmed instruction courses should include the sort of frank, fresh comments used by John Starkweather's group in writing programmed instruction. When one of his programs cannot answer a question, it suggests that you look it up in the encyclopedia, and the programs contain other things of this sort. In other words, attention should be paid to the amenities and to the humane character of the response.

Eighth, incorporated in the system should be a simulation of the matter-energy flows and of the information flows through the various subsystems of the university and of the community in which it is embedded. This simulation should contain both the actual physical structure of the university, with the spatial distances,and the administrative structure, that is, the channels through which information appropriately flows, the table of organization, and so on. It should include the relations of the various administrative and physical boundaries of the university to the community, and the sources of the inputs and outputs to the university in the community. It should include historical records of the changes in these over time so that the growth of the university can be studied, so that the simulation can be moved back to an earlier period in time to see what changes in structure and process have taken place within the system over time. It should also be possible to use a comilation technique into the future from the simulation as a basic means for future planning of the university. There should be an option to present this material graphically as well as in the form of charts or answers to specific questions, because many people do think about these things more effectively in graphic format. It also should be possible to question the simulation about a specific aspect without having to see the entire simulation presented in detail.

Ninth, there should be a data base for simulation and for question-answering. In general, this data base would not be presented in the form of tables or charts but simply to answer the question that managementmay have at the moment. Data should include the high school records, transcripts, evidences of performance, and other admission data of students.

It should include as much as can be obtained of the metropolitan data base of the community which is highly relevant to the relations of the university with the community. All regential and other rules and regulations should be in the collection and should be updated so that the manager or administrator can know that he receives the current rule of procedure when he questions the system. There should be updated information on the other colleges and universities with which the university interacts in various ways. There should be student, faculty, and staff performance records and activity records. Questionably, all administrative memos might be included in the system. They could be inserted at the source by the typewriters on which the secretaries type these memos, or perhaps inserted by the administrators themselves as they type at their own consoles. I say questionably; and I shall raise this issue again. There are strong pros and cons about this, and it can create a very important administrative issue if this kind of information is available to all administrators, especially top administrators.

The cost of all items, of personnel time, of space, of materials, of information flow, should, wherever possible be put in in parallel along with the information about those items. This makes possible the determination of cost for various types of cost-effectiveness studies.

And finally, there should be, in the total system, connection with networks to other universities, as I mentioned before, to provide a "university without walls"which is really national or international in scope. This would make possible a smallness which in the past we have not been able to have in universities. In other words, if the entire corpus of programmed instruction and documents necessary for a major university were available on a national or international network, then undergraduate colleges would not have to group themselves so closely into the large universities and the huge campuses that we are developing at the present. They could be scattered all over the countryside in different types of urban and rural communities. The emphasis and atmosphere of the small college, the personal contacts between faculty and students, could be maintained. At the same time the faculty would still be able to do front-line research, and faculty and students would have access to a library as vast as the total store of knowledge. This is a goal which can well alter basic planning of colleges and universities in the future, it seems to me.

So much for the technologies which might be included in the system. The next important question about information flow for management is the development of criteria. Over and over again in the questions which have been raised we hear: What is the criterion of adequate education or appropriate programmed instruction? How do you select the types of document that you want to have available for the students? What are the criteria for time allocations of faculty or space allocation or rooms? Some clear-cut thinking about criteria needs to be done in order to plan the future of the university, and also to determine cost effectiveness.

Now effectiveness in universities is obviously not the same think as effectiveness in factories or effectiveness in a government agency, and the very phrase "cost effectiveness" is likely to raise the hackles of any member of the university community. Nevertheless, if we are able more clearly to determine criteria (and educational criteria have been difficult to determine throughout the whole history of education), perhaps in some limited way this concept can also be applied to the university.

In order to go about this, first of all, I think that the computer and all the techniques we've been talking about should be used in every way possible to get the overload off the executives so that they have time to think about this. Robert Hutchins said that a university was not properly administered until all the responsibilites of the top executive had been allocated to other people so that he had nothing to do; and then he would find that he had a full-time job thinking about the problems of the university.

Now what possible goals can a university have? Externally there are proper university-community relationships. A university produces educated ladies and gentlemen, perhaps, or perhaps it produces married socialized ladies and gentlemen, which is a different thing, or perhaps it produces useful citizens, or perhaps contributing workers. Perhaps the main purpose of the university is not to produce human outputs at all but to produce ideas. Perhaps it is to produce leaders, who, instead of conforming to the society, irritate it and irritate the legislators. It may be that the purpose of the university is to achieve proper conformity-innovation ratio between the society and the university, and perhaps this is why the universities are always out of phase with society--so the notion of somehow getting the university to conform to its environment is mistaken because any organization that leads, is, by definition, not conforming to the environment.

Then there are problems of relations to the trustees or regents, to the alumni, to the parents, to the government, to other institutions in the community, and the criteria must be determined as to what these should be.

There are other types of internal criteria--the accuracy of information flow, the speed of information flow, the completeness of information flow; the best cost effectiveness ratio of information flows or matter-energy flows within the university; the speed of rate of learning of the average student, of the best student, of the minimal student; the generality of learning or the depth of specializing of learning of the student; an increase in the overall amount of scholarship or research; or an increase in the overall amount of teaching. Or the criteria may be social--the percentage of those encounters by a given student with people who are known personally to that student; that is, the amount of personal as opposed to impersonal contact. Or the number of student-faculty contacts or student-student contacts. Perhaps the purpose of the university is to improve the careers and increase the convenience of the faculty, and this shouldn't be laughed at because it is necessary to keep this variable within a certain range in order to keep the faculty.

Now these are certain forms of effectiveness of universities which are obviously in conflict in many ways. Yet any one of them can be maximized or minimized, and each of them has its costs. Management might well use a big data base and simulation to help plan and work on these sorts of things.

Until these criteria are determined and made specific, many things cannot be optimized and maximized in the university. This is why it is logically prior to determine criteria although, of course, they will constantly be reevaluated and they are extraordinarily difficult things, as I said before, to evaluate.

With this sort of system operating, what explicity, can academic administrators do? Innumerable examples can be given, and there is not enough time to mention all that come to mind. But first of all, there are the problems of external relations. Traditionally, in universities this is the primary problem of the president of the university or the official of the campus, with his second-in-command usually responsible more for the internal relations. But there are many types of specific questions about external relations that can be asked of the data base. Obviously if you have a description of the total community around you, the other universities in the country, the government agencies with which you interact, and so on, you can ask all sorts of questions. For example: How does the ratio of grant versus state funds for each discipline vary in our university as compared to any other given university? Are we putting too much state funds into the humanities and too little into the sciences, or vice-versa? Of course, a question about too much or too little has to be answered in terms of some criterion statement, but you can collect the objective data. Many other examples could be given of this sort of question, which fundamentally is not asked by administrators because they know they cannot get the answers fast enough to be of any value, or that obtaining the answer is too expensive. This is why a system of this sort will provide a form of depth of management and planning that has not been available before. Expensive though it may be to get the data base into storage, the values that can come out of such a combination of questions are also great. (Incidentally, this may be done on an interuniversity basis rather than at one plase since many of these things are of common interest to other comparable organizations, and that will cut down the cost.)

You may want to know the terms of office of all the legislators in your state. You may want to be able to break down the activities of your university in terms of their particular districts and the students or the parents who are in each district, and to inform the legislators in advance of extension activities or lectures or other things of this sort that are going on in their areas. At the present time, it's just too difficult to get that sort of information, and yet it can be of great in public relations activities.

There are students in every university who are related to almost every sector of the society. There are faculty members who are members of almost all the civic organizations and churches and perhaps are stockholders or members of families of management or corporations, and so on. To be able to identify these relationship is important to a competent administrator who is trying to interpret the role of the university in the community.

Also, it should be possible to ask of the data base questions concerning the educational needs of the community or different sectors of the society, and whether or not the extension courses and the basic curriculum are meeting these needs. Questions could be asked about changes in various types and categories of personnel as a result of automation, about other occupational alterations in the labor force, about the extent to which the university is meeting its responsibilites to labor, to agriculture, to management and so on. These are examples of a few of the many types of questions that should be asked.

To develop such a data base is not all that is necessary, of course. To develop a sophisticated question-answering system that can handle questions of this sort is important. There are increasingly sophisticated command and control question-answering programming systems that have been developed by each of the Armed Forces and also by the Department of Defense as whole. It has alreay been suggested that programs of this sort could be adapted for use with the university systems.

As far as internal relations are concerned, first of all, there are the students. You will want the individual data concerning the students, their intellectual history, data concerning their emotional history, physical condition, financial condition, the financial relations they have with the university and so on. I think this is one of many examples which illustrate why it is fundamentally irrational to separate the administrative computer system from the academic computer system. The student who has a health problem and who has an academic record is the same student who pays tuition and fees. In a university hospital, the patient who pays fees is the same one who receives medication and whose hospital record is used for medical research and epidemiological public health research. The library book which is read by a scholar is the same book that has to be purchased, shelved, and recorded. Moreover, it is much easier to make cost effectiveness studies if the cost and the content are related in the same system rather than in entirely different systems.

It is possible to use on-line computers for student testing, for personality testing, to keep updated, continual records about the student, and to inform the appropriate advisor whenever a student's record falls within a range where some form of advice or counseling is indicated.

It is also possible to break down courses into smaller units, perhaps down to the equivalent of a single lecture hour or a single-tape television unit or programmed instruction unit, and to thus give much more specialized attention to each individual student. I feel that this is highly desirable but that there are certain conditions which must be met before such specialized attention is feasible. First the library of smaller units must be available.

Second, I think that an ongoing management program which arranges courses and classrooms, and schedules the students into them in terms of courses, is probably a practical prerequisite to the development of the more sophisticated individual programming of each student who is progressing at his own rate and who is dealing in one or another corequisite or prerequisite smaller unit of information. Ultimately, certainly, we should work toward the elimination of formal course arrangements and scheduling arrangements that serve to retard the learning process, and instead make the system as adaptable as possible to individuals, who obviously do not move in lockstep. It is important, it seems to me, for all of this to be part of the simulation, because many of the criterion evaluations which the administration of the university must make must be made in terms of evidence derived from students' performances on programmed instruction and other forms of instruction obtained from the individualized student carrels or terminals.

Another area in which computers could be useful is the awarding of fellowships and scholarships. Universities have large collections of fellowships with all sorts of specifications as to whom they should be given. One might be only for missionaries planning to go to Nigeria or one is for residents of Herkimer County, New York, or one is for people under 21, and so. This can be as complicated as scheduling classrooms, and obviously is a natural for computer treatment. There are now so many different kinds of loans and grants available that often a student cannot tell whether a loan or grant is going to maximize his financial interest. Very possibly a computer can help answer that question.

There is the problem of teacher evaluation that was mentioned earlier. It seems to be that one of the primary problems of evaluation of teaching is that teaching is looked upon by the average professor as an idiosyncratic activity. He would as soon have you break into his home without a warrant as have you or one of his colleagues sit in on one of his lectures for the purpose of evaluation. There is reasonable skepticism about student evaluation because of recognized student bias, and there are many other problems. If teaching ability cannot be evaluated, it obviously will not be weighed heavily in promotion, no matter how much the administration may insist that teaching counts as much as research or administrative ability.

Some of these new technologies can help. First, the record of a given professor's students and their performance over the years can be evaluated much more readily with a data base of this sort. Second, if instructors voluntarily write programmed instruction courses or tape television lectures, it is possible for others to evaluate them, and complaints about such evaluation would be minimal just as complaints about the evaluation of textbooks as an indication of teaching skill are minimal.

Furthermore, if the programmed instruction or the television lectures are available on national networks, there is motivation for a professor to teach more. He can then get national immortality through teaching as well as through research, which is the only way to get national immortality at the present time. Also, some sort of idea of the comparative demands for his instructional activities on a national basis can be obtained. So I think that there are clear possibilities for teacher evaluation in these methods, and undoubtedly other possibilities will occur to others.

Collecting grades and informing students about their grades can be more rapid and done more efficiently. On-line programs can be used to grade tests and to provide the teacher not only with the grades for his class but also with means, standard deviation, items variance, correlations between items, grades and total grades, and other score correlations which are the fundamentals for the development of better testing procedures. It is possible to use computers to interpret to the student the interrelationships among tests, between psychological tests and contents tests. Often academic cousellors either do not have the background to make this sort of interpretation or find the number of variables involved so great that they do not have the time to calculate the interrelations and interactions themselves.

I shall not discuss the research activities of the faculty and staff, simply because that is not the purpose of this conference. We are emphasizing the instructional and administrative research aspects here.

All administrators should have terminals in their offices. The very existence of the terminal will cause them to ask questions of the data base and will, therefore, increase the depth of their planning. It will enable them to ask formerly unanswered questions. These terminals can contribute to the regulation of flows up and down within the system. I say can contribute: they do not have to contribute to flow regulation. You could use such a system and still have no regulations whatsoever as to who should communicate with whom.

In a very deep sense, the administrative structure of a great university is different from that of a business. One might almost say that one criterion of a great university is the ease with which each individual can communicate with each other. If the faculty are the university, then there is this freedom of communication. If the faculty works for the university or the regents or trustees, then this form of communication is limited, and there tends to be greater and greater insistence on channels of upward flow and downward flow. Simulation will, perhaps, show whether a particular university is great in this sense or not.

But, presumably, there must be some form of regulation and hierarchical organization. Then we can assume that there is the classical paradigm of organizations. The information flowing up is gradually abstracted or condensed and put into more general format at each echelon until it reaches the top administrator, decisions perhaps being imposed upon the information at each level as it goes up. On the way down, there is converse situation. At each level the implications of the directive are further spelled out; the information is made more specific; the reverse of that abstracting goes on until finally the directive is carried out.

Now if we accept the fact that this paradigm must exist to some extent, it would be possible to get some idea of the amount of noise in the total system by finding out the amount of error in administrative communications between levels. It would also be possible to determine the amount of distortion, that is, not random error but systematic distortion by a department chairman or a dean in order to emphasize the things which he thinks are important. The sum total of those distortions constitutes, of course, a great problem for the next higher administrative level.

Also, there is the problem of secrecy which I mentioned before. You may have either random distortion, which is noise, or systematic distortion, which is distortion, or complete blacking of the communication, which is secrecy. The problem of secrecy of administration is something which every administrator recognizes. If subsystems are not permitted to stop certain things at their boundaries, then they lose economy in a very significant sense. If, on the other hand, they withhold information which is administratively necessary, the overall efficiency of the organization breaks down. So the crucial question: Should all administrative memos be stored in the computer, and should it be possible for higher echelons to dip down at will into lower echelons? Or should this be prevented?

Administrators take both sides to this question. The top administrators take both sides of this question. The top administrator who dares say, "I will dip into administrative memo at will at any time", is a very strong administrator indeed because he is aware of two things. First, there will be hostilities engendered by this. Secondly, the memos will not carry the truth. Everything will be written for the eyes of God, and communications at lower levels which are written as for the Golden Book in Heaven are not accurate communications.

On the other hand, if the administrator decides not to dip in, then he does not take advantage of important forms of feedback and important forms of evaluation of the effectiveness of the communications system. So principles need to be worked out as to how extensively the relevant information will be used and who is entitled to it and who is not.

However, the important thing to recognize is that information flows in a university are, and should be, very different from those in a government agency or a business. One example of this is the fact that undoubtedly it should be possible for the consoles to communicate with each other at any level; sidewise communication as well as upward and downward communication should be possible and very broadly permitted. And a measure of the constraint of any organization is the amount of permitted sidewise communication.

On the other hand, universities are similar to other organizations in that knowledge is power. It is rare or unheard of for any administrator not to take advantage of knowledge he obtains, and if the administrator can receive automatic, distortion-free information from the lower echelons as well as or instead of abstracting information which comes through the administrative and lower echelons, he does have a form of power for use in integrating the organization and planning than he would not have otherwise.

A final example of how this sytem could be used in internal administration is the attaining of personal knowledge of faculty and students. It is impossible for the chancellor of a campus of 27,500 students to know or all of the faculty or all of the students or all the faculty wives. But there is no reason why he sould not know the names of these faculty members and their wives whom he knows he will see at dinner that night. If an administrator can have ready access to information on the people he will see in the next hour, it probably will be beneficial in the strengthening and underlining of the Oedipal-father role that every administrator must have.

A final point. What will the resistances be? The resistances will be tremendous. First of all, there is pure ignorance; ignorance of what the hardware is like what the software is like, ignorance of the form of control that computers can exert on man. I saw an example of animal ignorance and emotional reation in a very intelligent man who had had a very high administrative job in industry. He saw down before a remote Project MAC teletypewriter and actually broke into a sweat and refused to touch the typewriter because of his emotional fear of this intimate interaction which had been described to him, and he was a person who otherwise was highly stable. This is a reality; it has to be faced. Practically everyone I know who has talked to a public audience or to an audience of faculty about these developments has had either the second or the third question from the audience deal, in some form or other, with this animal fear, which has not been helped by recent science fiction. Perhaps we should take steps to skip the oppostion phase. A slow transition, which is the way it will have to be done in most cases, has the disadvantage of a continual comparison of the old and the new methods--and of course, we want to have that form of evaluation. We do not want to adopt methods which are not financially feasible and which are not improvements of basic educational concepts.

On the other hand, suppose you are establishing a lot of colleges in a new university, and you have one more residential college to set up. In addition to selecting the faculty by ordinary standards, why not also screen that faculty, in terms of their interest in experiments using these methods? Then make available to the faculty a semester or so, after the college has opened, to work out these methods as they will use them. Techniques like this, cautiously planned to avoid opposition, may well provide us with the first working models of systems of this sort.

Once such a system has been demonstrated in an atmosphere which the administrator makes as free of opposition as possible and in which experimentation is warmly encouraged, then its value for other aspects of the academic endeavor should be recognized and adopted elsewhere.

I think we must be willing to waste some money in some of these projects, because they will be expensive at first. If there are savings, the savings may never be financial; they may be savings simply in terms of the quality of education. There will not be savings in the first experiments or the first time the data base is stored, so money must somehow be found to throw away in experiments of this sort.

This seems to me to be a role for foundations and federal government. As Licklider suggested, perhaps one of the best ways to get a truly compact, efficient automated library is to convince NASA that such a library must be put into space. Then somehow the money will be there, and when it has been put into space, other copies will be available.

I think we all have to be aware of the fact that if we are involved in the use or the implementation of any ideas like these, we must spend a lot of our time in putlic relations activities. We must take the time to talk to the students and the faculty, and allow them to have personal with these techniques. My own experience has been that having a console that people can sit down and play with is the best type of public relations.

Perhaps the experience at Tulane University Center for Computer Aids to Medical Diagnosis has been as revealing as any. The Center staff simply went in and set up their program, which serves Tulane and the region around Tulane, and arranged to have lunch every day in the medical faculty dining room. They said nothing about what they were doing until people asked them. Then they simply described what they were doing. The first year they set up the system, nobody came to them. The second year they worked on some of their own projects; nobody came to them. The third year three departments came on their own initiative and asked if the Center could help in one thing or another. The fourth year there were 21 projects; the fifth year there were 110 projects, the Center was completely overloaded, and there was a project in every single department of the medical center. They never asked anyone to come, and by that well-known political trick of shyness, they let the member of the community very effectively discover for themselves the value of this sort of thing.

These systems will have to grow slowly. It is the concepts behind them and the software that are most needed, but I am convinved that they will come.

Thank you.

ALDRICH: Thank you very much. Jim has given us a great deal to react to. Mr. Rieser has been jotting down an item or two as Jim has been commenting and will provide us opportunity for focusing attention following a coffee break. There is an opportunity now for you to comment or raise questions that might be added to the ideas set forth by Jim so that we can address ourselves not only to what he set in motion but what you would like to set in motion as a consequence. SELFRIDGE: Jim, I hate to broaden your semi-instant scope, but I'd like to raise another aspect, the problem of a department of computer technology, what a university should do about it? I'm not sure a computer department is the right title. I agree with, I guess, Lick, who thinks it ought to be something more like Information Technology, which I must say represents the sort of field I had in mind. It seems to me that the information sciences department or information technology has a special role in the university, enlarges the role of education, but it's not looking at something else; it's looking at itself as part of its own subject. I think we should be very careful about doing this because it seems to me most schools of education have failed, and I can judge this by having read numbers of doctor theses, and here I will use the word "so-called" doctor theses, in education. I think we should be concerned with setting it up. It seems to me that one of the roles of coordination for the Interuniversity Communications Council, which Jim Miller is involved with, might be to see what is required to set up standards to get together courses to cooperate with other universities who are about to do this. My feeling is that in the next five years, every large university of any ambition or standing will, in fact, have new departments where most do not now for such a field. This is one field where we might really practice the beginnings of doing it right, in the sense of trying to set up the data base with respect to this very problem itself. I would hate to see the department set up by means of innumerable conferences. Conferences are very nice, but what is needed here is much more a continual, day-to-day working and cooperation between people in different universities and certainly in different departments in the same university, working together to work toward something which, in fact, has to be done.

I'd like to change my topic a little bit to something you said about protecting the files and access. I perhaps think this is even more important than you do. This morning's talk seems to me was a very clear indication of some of the dangers. With the best will in the world, Mr. Blakesley was accumulating enormous power for himself in deciding who was to get what information and who was going to do it. I have infinite respect for his good will and sincerity; nevertheless, he was, in fact, freezing the system in spite of his avowals of flexibility. Somewhere it says, "Ye shall know the truth, and the truth shall make you free." If I'm the one who decides what truth you'll know, then I'm the one with all the power, whatever the other guy thinks he may be deciding. It seems to me some of the danger of this, someone running a data bank or running a computer center or running an information service center, has to be incredibly careful not to make any of the decisions, not to decide who should get what information, but to be a real service, and it's very easy if I'm controlling flow of information to seize power, and I may be the wrong one to do it. If I have control of information flow very probably then I have absolute power. FLOOD: Many of the things that Jim said were good ideas, but there are also good ideas which are as useful outside the university for top management as they are inside. For two reasons I think it would be very interesting to try to sift out the things that we think are peculiar to universities and peculiar opportunities in universities. One is, nobody else is going to do that except groups like this, and the other one is that the other kinds of things can be worked on vigorously in many other kinds of organizations such as industry and government. I think it would be nice, at least, to recognize their differences. STARKWEATHER: In the current systems which do allow some form of this on-line intellectual community, are there instances known by those who are close to these systems of administrators or people with administrative responsibility who are trained to make use of this facility at the moment for administrative ends of this sort? SHARP: In connection with Dr. Selfridge's comment and Dr. Flood's, I would like to mention one of the facts of large state universities that I'm connected with, which places more than just a technical problem in front of this type of a system, and that is a political one: The fact that there are departments of very great unequal political power and also the fact that this is an unstable balance, which will mean that any system will be constantly butting against pressures that change. MURNIN: I stayed on what I thought was secure ground during the past part of this conference. However, I'm very much impressed with the

Irvine campus. I did notice that there is more empty space than there are buildings, which indicates to me that we have a very unique situation here. We have what I would consider a total institutional laboratory. We have an institution which is not strapped, as it were, by the usual traditions of the ivy-covered university. I consider this a unique opportunity to get some good research and development off the ground. If the Office of Education is not aware of this, I certainly shall carry the message back. ALDRICH: I'll react immediately on this. I'm delighted to hear that. MURNIN: I think that Dr. Miller even did a better job than I did in considering the urgent concern of the Higher Education Research Branch of the Office of Education. But it also seems to me that Dr. Aldrich has problems which are in the fairly immediate future and I may be expressing ignorance, but I was wondering if we should be working toward getting something off the ground in terms of Irvine. Would it be possible to develop an administrative model which could perhaps in the near future give Dr. Aldrich some of the answers he's going to have to come up with? Let me add this: If you envision such a model to be practical in terms of its manipulation of administrative decisions, what parameters do you feel it should include, that is, to initiate such a model. And if it's a dynamic model, of course we know it can be built upon. FLOOD: I thought I'd just add a little comment to what Mr. Murnin said. I'd be very interested in some discussion of experimental opportunities, particularly with respect to new campuses such as Irvine, compared with others in which you take observational and controlled experimentation.

TSCHIRGI: Mr. Murnin, is it possible that through a data base and the use of the computer-type facilities in the administrative aspects of universities that we might begin to approach some meaningful analysis of the output of the university? If, as Jim Miller pointed out, one of our goals is to examine the quality of the university's function, it seems to me it's very important that we must overcome the present absurdity of measuring the effectiveness of the university on the basis of its input, not of its output. Primarily we make our analyses on how much raw material does it take in and then chew up in whatever way it chews it up and we pay little attention to what actually comes out of the thing. We analyze it on the basis of the raw material input, and although I admit I don't like to make analogies between universities and industry, nevertheless to the extent that such analogies are appropriate, it seems pretty absurd. I can't imagine industry who would evaluate itself on the basis of how much raw material it uses.

LICKLIDER: I'd like to mention the other side of the coin. Merrill Flood suggested that we see what is peculiar to universities about the kinds of information processing systems we're talking about. I think, at the same time, it might be worthwhile seeing what advantage we can manage to take from work that's been done in military command and control of intelligence data-processing and management information systems in business and industry.

ALDRICH: Mr. Miller commenced with a plea for establishing an information center. However, as we moved among several points that Jim made, it seemed to me that what we were concerned about with this information center was the development of those resources which enabled us to bring together and talk about multi-purpose units and multi-media approaches, etc. The kinds of data related to every dimension of university life that enabled those concerned about decision-making within the university to simulate various aspects of university life into which this data might be plugged and, as a consequence of plugging it in, enabled those who were responsible for making decisions at any point in the system to do so, hopefully intelligently, based upon facts, information, data at hand. So we've got the center, a capability within the center for simulation of the university organism and the need, if this capability of data-gathering and model simulation or university structure simulation cranked up within this setup up for implementation. Jim went on to comment about the varied concerns involving faculty, students, administration, internal relations, external relations that all must be borne in mind, constructing an appropriate simulation of this organism or system called the university, and, on the other hand, generating the data base that allows for the appropriate injection into the model or the simulated construct. It seems to me that this brings us then to the questions that were raised. One, by Oliver Selfridge, where in this organism called the university do you have the departments of informational science and technology which he is concerned about because perhaps herein is the entity in the university to develop the simulation technology, studying itself, studying the university as a whole. I would expect in such study also shedding light on the appropriateness of the machinery for developing the data base. Merrill Flood commented about the fact that within the past several days, reference has been made to the similarity between data-gathering perhaps, the development of a data base, simulation between industry and universities, but there are some unique characteristics, presumably, about a university, and perhaps this group should concern itself with it because if we don't, perhaps no one else will. John Starkweather then raised the question that if we have within the universities of this country the wherewithal to develop a data base to the mechanism for simulation, the machinery, therefore, for administration to relate itself via this science of technology to decision-making, is any administration doing so? This is essentially what I have reconstructed out of the commentary that was developed by Jim and questions that were raised. You can either proceed now on the basis of going back to your own estimate of what Jim set forth and the questions that were raised or perhaps addressing yourself to the items on the board which essentially relate to simulation, on the one hand, and implementation on the other. Maybe I've done nothing more than confuse everyone.

INFORMATION CENTER

- Simulation of University
    - Scope and Practice
    - Data Input
- Implementation
    - Dept. of Information Sciences
    - Experience in University and Business
    - Resistances

CORRIGAN: I'd be interested in extending this discussion to attend to the question of what should be the products of the university and what should be the specifications of those products or output? I think that unless we define it we cannot really state what the functions of the university should be to produce those products.
DAVIES: Maybe what we need is something that might be impossible, simulation of the society that the university is imbedded in. The purpose of the university is very broad and to even decide what that purpose is and then to determine the extent to which you are fulfilling this purpose seems to me to require that you look at the system that the university is imbedded in and try to determine whether results are long-term. The results of education don't have their full impact until many years after the students have left, at least that's one kind of university. There are others, too, but we're talking about some rather revolutionary changes in the ways that universities are going to conduct their business. As long as you stick to a certain pattern, you can say that to a certain degree you're satisfied or dissatisfied with the way that pattern has been working, but at least there is a lot of historical basis on which to make decisions about my evaluation. Now if we're going to introduce very rapid and revolutionary changes in approaches to education, we should, I think, be particularly concerned about what the effects are going to be and give attention to how we can determine what these effects are as quickly and accurately as possible, and that won't be very quickly or very accurately. MILLER: In response to that, I'd like to underline agreement with what Bob Tschirgi said, that perhaps it would be

best if we were to take the idea of simulation seriously -- simulation in the university and the community and their interaction. We pay attention, first of all, to the output of the university rather than the input. In other words, we often are told we have this many students and this much money. Since we're not quite sure what we want to do with them, then we make do as best we can. If, instead, we say one of the things we are trying to maximize is output (and you can't talk about the purpose of the university any more than you can about the purpose of any other large organization, it's a very complex, multiple purpose, associated with the different criteria of which I listed consisting of many possible ones) but although it was implicit in what I said, I think perhaps we should extend this idea beyond the intellectual community to the notion of participation by the students and the faculty and representatives of the community in the development and evaluation of the simulation. If it is on-line let them play with it and look on what are the implications for maximizing one or another of these multiple and oftentimes conflicting criteria of output. Then let them face frankly the problem of the costs that go along with it, the limitations of the ability of the state and the federal government and private sources to support education and matters of this sort. Perhaps one of the most effective ways, in terms of the university and the community, would be to have a concrete simulation, which they could have access to at their own terminals, which at first would be simple but would grow in complexity and on which they could interact. I can imagine student newspapers writing all sorts of editorials on why you're maximizing this rather than that and so on; I would think that this sort of participation on evaluating the criteria, evaluating the means, would be worthwhile.

ALDRICH: May I just raise this point, Jim. When you speak of the output of the university, you're not concerned alone with the student product.

MILLER: I mean the problem of short-range and long-range maximization that you talked about.

GERARD: We have had the suggestion made earlier this afternoon of effectively simulating a university. We've just been told that in order to do this meaningfully and know what we want to optimize, we must simulate a society. Earlier in the week, it was pointed out that it was going to be possible to simulate a student and experiment with what kinds of educational experiences would work best with the simulated student before we expose the real student to them. These are very fine notions, and I happen to be a Cloud 9 man mayself, but I would very much welcome some hard-nosed reaction from the people who have actually dealt with these things as to the reality, the possibility in the finite future and with the budgets available through the federal government, of achieving these, or to what degree all these fine things are conceivably achievable. I am reminded of some concrete simulation experiments such "Leviathan" tested a simulated society in a small way at SDC by Sydney and Beatrice Rome, which has been going on for the past five years now which I don't think has yielded anything breathtaking. Can we do it, in other words, gentlemen? GOODMAN: I think maybe this is Cloud 8, if not 9, it's out there pretty far. I'd like to pass along some thinking that was done at a rather informal seminar this summer in the Office of Education by a group of people associated with the National Center for Educational Statistics. We were concerned with the problem of measuring output. Two things we said we didn't want to limit were __________ and measuring the output of the student. Instead of taking the tasks prerequisite, you should simulate the whole ______________.

One of the notions we arrived at was to simulate certain types of behavior in the forms of games that you would like your students to be able to play if they're the kind you would like your students to turn out to be. Then you would simply have a battery of these games that could be called ___________ and measure the performance of these people playing these games, comparing them with the educational experiences they had. The more people thought about that, the more they realized it's not an inconceivably difficult task to do. We remain with the question as to how generalizable the results would be. We're not too far off because it involves a fundamental intelligence or achievement test when you're talking about asking someone to play a game. However, you cannot stretch certain phenomenons in society to say that to do this well would mean that one is performing certain skills, has certain knowledge and so forth. The batteries of these games could simulate certain aspects of society. SHARP: I was going to state the fact that I had heard of chess playing as an activity that people have taken rather seriously, but one of the failures that Professor Licklider told me about at MIT is that when a person did poorly in the chess game or when the program did poorly, the analysis couldn't agree on what he had done wrong. They knew he'd lost but they couldn't abstract enough information from this very simplified situation to learn too much. FLOOD: I had a comment I wanted to make with respect to that Cloud 8 1/2 remark. Dick Atkinson said that he attends many conferences like this and I certainly do, too, where we sit around and dream about all the fine things that can certainly be done someday, and, of course, they'll happen someday. But I'm reminded that when I visited Irvine(this is no reflection on either IBM or Irvine), Julian Feldman couldn't get the punch card transmitted to UCLA because there was something wrong with the 1050 punch. That happens all the time and I can cite example after example of how just recently the director of Project MAC and I were complaining that we can't get any service out of it now because they're putting in new files structures, which will be great when it works; but the minute they get it barely working, then they'll do the next thing. So I think the point I wanted to make was: in response to Ralph's remarks about the shorter-range thing, I think that everything takes at least three to five years, no matter how simple it is. I think that all the things we talk about here will take years. On the other hand, I have a personal feeling that we probably can't think of anything we can't do in ten years until research is put into it. I just think it's really difficult for people like Dick Atkinson and I hope I can be included and I know Oliver can be, when we do our own little jobs, nothing works. It's just impossible. On the other hand, over a period of time, a great deal happens. KOPSTEIN: I want to respond to Dean Gerard in his request that someone speak who has had a little bit of experience of what happens when one tries to suggest things of the sort brought up by Mr. Davies, including, for example, the notion of simulating a society, to derive from it criteria for the output of an educational system. This has been done.I think that the real difficulty here is that you're dealing with extremely complex and abstract concepts. This sort of thing is easily understood in groups such as this one, but have you thought about the problems of trying to make this even halfway understandable to society at large and to get them to hold still long enough to really explain this in depth? I think this is the great difficulty; it'll be inevitably misunderstood if one were to try and immediately implement such things. MILLER: I agree with Merrill Flood that until the computer system gets debugged, the next campus opened by the University of California should not be a simulated campus operated by a simulated chancellor and a simulated dean. On the other hand, for lack of time, I skipped a reference I was going to give about an actual simulation of a minor and limited sort that was carried out. ________ and Terrell of St. Louis Junior College have been planning a college of 4,500 students by a simulation technique based on GASP from MIT. The simulation increased the actual utilization of classrooms to 88% and 66% utilization of laboratories. They say that in using this to plan their college, they conservatively saved the college three million dollars. They ended their summary by stating that utilization would probably be better if it were planned by a master program. This is a report from literature. SELFRIDGE: I think he's confusing simulation with something else. We all simulate chancellors, deans, and bursars especially simulate. They have a great model that says if you ship them an invoice, you're going to ship a check back with it. For that question it's just as much a model for a simulated model. With respect to the simulation that Dr. Miller was talking about, it was to answer specific questions in planning, not to make demonstrations to the public or to make anything more lively than that. And in that case, the simulation is just as complex as it needs to be. It may be that you have to build the whole man. Economists suspect so for some economic models, but for many of the models in planning universities, I'm fairly convinced at the present that you don't need a terribly complicated model to simulate something that will effectively answer the questions that the planners need. ALDRICH: I'm delighted that I gave you a chance to speak before I did for the simple reason that I have decisions to make every single day - whether it's providing Hitch with information on whether it takes this much to produce a space or to account for this or that, or other things. I'm confident that there are resources of hardware and software, models, simulated and otherwise, that would make our business here easier and more efficient and let the faculty and the students go about the primary business of learning, interacting, whereas presently using these antiquated methods bogs down in committees trying to find out information somebody else wants. And very frankly, I have a very simple view of my job as an administrator, and this relates to the topic of top flow information. That is: how to create an environment and a climate in which students and faculty, who are the principal ingredients in a university, can spend most of their time doing that instead of fiddling with the things that keep the house or the machinery going. MILLER: I understand that one of your early tasks was to prove that you would need 1,500 rather than 500 entering students for the first year, and you did it by the number of students graduating in a nearby high schools. This seems like such an obvious thing to get from even a simple data base that that task would have been probably greatly simplified by even a primitive model. HITCH: I suppose I'm a Cloud 1 man as befits a controller. I welcomed very much Tschirgi's remarks on input and output. It isn't only in the educational field that it's common to measure output by input. It's long been fashionable, for example, in the military to measure military strengths by the number of men in the service and the size of the military budget and these are both input. I think it's terribly important that we get our thinking straight about input and output. Input is something that you minimize, not maximize, and you continue to maximize output, and the difference between the two. I certainly wouldn't want to discourage anyone from making a direct attack on the definition and the measurement of output or objectives, but I think that is hard. It's terribly hard in the university. It's terribly hard in military but I do want to emphasize that there are just so many things that you can do and can learn from analysis and from simulation without making very much progress in the definition and measurement of the output. You can do all of these input studies that Jim has just referred to. You can achieve the same output by what, in the best judgment of the best informed people, seems to be equivalent output, and save 30% or 10% or 2%, which is still an awful lot of what it's costing you to achieve it. MURNIN: It seemed to me when I made my earlier remarks that what I was thinking about was not to simulate the community or simulate a man. This may be in the future and I'm sure that Dr. Miller meant it to be in the future. But I think what I'm interested in from the Office of Education point is the climate of learning that you described in which the faculty and students have more chance to interact and are not spending alot of their time in meetings, committees, etc., just to keep the house going. And what I'm interested in, for maybe obvious reasons is: is it feasible to develop and get off the ground an administrative simulated model that will give us a chance to operate and to make administrative decisions? Can you build these things or can't you? I get the impression from some of the remarks that you'll spend four or five years doing this. Is this true? I don't think Dr. Aldrich can wait four or five years. By that time, he'll be up to his 30,000 students. STARKWEATHER: He needs an information center, regardless of whether it has a group within it carrying on simulation experiments. I think there is a partial separation that can be made. If he had an information center that was working to some extent in providing even some of the information he gets directly or indirectly by other means now, if he had it in such a form that it was acceptable, was able to interact from one part of it with another, was a part of a kind of data base we've been talking about, then I think relative forms of simulation by him and his associates and other people would naturally begin to occur. I can't really have any doubts that these uses of trials of various combinations of the data and looking at it and entering into simulation-type work wouldn't begin to occur if the mechanism began to get built for his current practical needs. LICKLIDER: There is an interesting small group of social psychological phenomenon going on here in the last few minutes. I was feeling that this whole thing had gotten too far up in the stratosphere for my respiratory mechanism. The reason I wanted to comment is that I think I see why. It's the occurrence of simulation at the top of a list of things that you might do to come to grips with the problem and get started. I don't think that's what was meant by the people who have been mentioning simulation earlier, unless Oliver is right. I don't think when we were talking about simulating students or universities or anything else, we really meant the simple kind of modeling that you do in the course of planning. I think that there are two things. If that's what's meant, fine, that's all right - you do have to do some simple modeling on the back of an envelope in planning, but once you get an information sciences department and an information center and you have people who are trying to come to grips with how all this ought to work, they will be making simulations of the university, but that's not how to get started. How to get started, I think, is very much simpler. The way to get started is not to make a deep and profound analysis of what a university is and then to design a vast command and control system to make it be that because the experience that I'm familiar with says that complicated things just get to be too much in the building of that command and control system and a management information system never gets accomplished. The whole thing bogs down in unhappiness. I think the way to go is to see that there are some fairly obvious functions that have to be fulfilled and in some of these functions the computer system will be helpful and, indeed, a data base will be helpful, too. In the functions that deal with top level administration, these may depend considerably on the style of the administrator. I hope not in the long run, but I suspect so at first. And so I think you have to work closely with people who are trying to figure out what are the highest priority things in your need structure. Which of those can be implemented? How can you be helped? This will go on concurrently with CAI, with the scheduling of room allocations. A data base will develop from a lot of concurrent activities, but you can't wait for it in order to have something that you can ask your questions of. You must think about what questions you're going to ask and then collect the necessary data and devise a mechanism for asking the questions. MURNIN: I think that Licklider answered the question. In other words, what you're saying is that this can be done. LICKLIDER: I was trying to say two things: that it can be done now and it's out of the top of the head, fairly fast, but not in an elegant way, just in a workable way. It can also be done rather elegantly in such a way that it elevates the whole art of doing these things, but over a period of years. ALDRICH: In this regard, in our own experience, we knew we didn't have the resources to utilize, as we began over here with the electronic data processing, computer technology in the operation of this thing that was to come into being. But we did have access to a group of people in the university-wide system who could say to us: as you begin your manual operations and planning, here is how we would propose you prepare yourself so that when you do reach this critical situation, you are in position to apply the state-of-the-art at that time. In other words, we don't want to be moving in one direction and knowing that there was a point in time when we could utilize science and technology to our advantage and not have put ourselves in the best position to do so. And I would say that, from what has been said here in the past few minutes, simulation is possible at the present time within various areas of the university, its operations, administrations; the construction of a system that would enable you to get results that are helpful, but all the while (and this is what I come back to to figure out whether I'm on the beam with Oliver Selfridge or not) is that here is this information science and communications center that is working at the more elegant construction of the art or development of it. Presumably, at a point along the way, we discard a way of doing business to take on this more sophisticated approach that has many possibilities for it. Is this combining these two notions of Licklider and Selfridge?

SELFRIDGE: Simulations or models can progress very straightforwardly. Let's take some of the examples from this morning. You have model of a student which says that, as an average student, which, itself, you understand, may set the purpose to begin with; he's going to want to change certain numbers of courses, he's going to want to do certain things with his time, and you decide whether he wants to do this. Later on, when you're suddenly out of patience with that deluge of information which clearly is available, may be deluged with two weeks of work, you notice that some of these students don't necessarily. That it is more feasible, more reasonable, it gets you more accurate answers, if you divide students into certain kinds of classes. Give him a parameter as to how likely to be orderly and conventional he is, and maybe other types only want to study late at night or something like this. As these notions evolve, your model of the student is getting more and more complicated, and presumably you're getting more accurate answers. At some point you may have to go into his emoitional life. Who knows? It seems to me that to get started at all is having a procedure which can look at these, which can look at the data, and make reasonable generalizations--you can leap from one to the other--and get started right now.

MILLER: To Dr. Murnin's question about whether there can be parameters of a university could be used for such a simulation, I have here a memorandum that I wrote in 1957 when we at Michigan were just beginning to think about residential collegs. It suggests what the parameters of such a simulation should be. It even indicates a lot of illustrative propositions concerning universities and simulation that might be tested. But it sat around, partly because there wasn't any one person that was wanting to spend full time on it and partly because the necessary computer facilities and so on were not available. If there were $50,000 available to start a study of this sort, I notice that this one that was proposed today is three million, very likely you could get quite a distance with such a thing in a couple of years. You could not answer most of these propositions, for example, whether or not there is more demand for a university than for a state with higher social mobility than one with lower, or is there more demand for a university in a community that needs higher specialized skills, or the proportion of the budget going into administration increases with the size of institutions, or the average size of departments increases slower than the size of the institution as a whole because the subdivisions increase in number. Things like this, which are long-range questions, couldn't be answered. But on the other hand, you could very likely get some good evidence about simple matters, like, who talks to who and plans between faculty and students and where and how much. Who writes to whom, on the basis of which, in planning a new campus, you might decide which groups of buildings to put together in a more rational way than we have at the moment about it. And also, perhaps, in some ways you could save cost. Questions of who uses TV or computerized instruction and plans by types of students, undergraduate, graduate, medical students, law students--issues of this sort are relatively simple ones which in a couple of years we should begin to get some sort of answers to.

DAVIES: I think there are two questions that we're dealing with. Is the new university that is being formed going to perform the basic functions, whatever the basic functions are, taking in the students, and taking in the curriculum and graduating them and is it doing this efficiently and so forth and at reasonable cost? The other question is: what is the quality of the product that is being produced? It might be instructive to consider the manufacturing business and see how they go about some of this. Let's take the semiconductor business. They have an input and they do things to it and they produce transistors and dials. They first have to determine what is the purpose of the transistor; they try to take certain parameters by which they'll be able to predict the performance of transistors. Maybe they decide that you want to measure time delay or something because if you can get these within certain specifications, then you know that the transistor will perform the function that was eventually intended for it. As a matter of fact, you might have heard that radar discovered a new function for the transistor and then decided that you have to measure a new parameter. It seems to me that it's terribly important to do that kind of thing with regard to the university. I think we have to ask the question: what are the proper products of the university? Then we have to see if we can't discover what are some measures that will give us some ability to predict that these functions will be performed well, whatever we produce. Maybe you can do such things as isolate certain characteristics. We wanted to produce human beings that have certain characteristics. Can we identify classes of people that exhibit these characteristics? Can we find certain measures that identify these individuals? Can these measures be used as a basis of evaluating certain things that we're doing in the university?

KOPSTEIN: I feel compelled to add to this and try and straighten out a confusion that I think exists with respect to what I said earlier and it's apparent from Oliver's comment on it. Consider that in trying to determine the output of a university, you have to have some criteria unless it's to be completely arbitrary. And it's been suggested that these criteria stem from the society into which the university feeds. I agree that with respect to Dr. Selfridge's comment you can get by with a very simple simulation. The simulation that I was talking about earlier would be one of the society, even in a very limited sense, maybe with respect to the labor market within it, and it would be there for the purposes of extrapolating into the future, so that you can, from this extrapolation, determine what you should be trying to produce in the way of output, now or at any such time. Consider that there is a problem of the phase relationship, inasmuch as you are now in a position of having to plan an output over a number of years, and this output, in turn, is going to be active within that society or just the labor market at a still later time. The nature or the knowledge or skills, let's say, that the output has to have in part is going to be determined by the fole that these people are going to play in society. They don't always play the same roles when they first get out of school as they play ten or twenty years later. This is where I tried to say that a simulation of society can be useful and can be important, but at the same time, this kind of notion is very hard to get across to those people who, within our customs and legal structure, ultimately determine what the output of the university should be.

TSCHIRGI: A couple of comments from a naive point of view because I'm very naive in this area. It seems to me with respect to the Cloud 1 situation that Mr. Murnin and Mr. Licklider have commented on and the Cloud 9 situation which some of the rest of us have been commenting on, that there is a community here, that it's a level of difficulty problem rather than a problem of kind. For example, is it not possible that by carefully defining input and output we can do something on a Cloud 1 level right away? As an example, if the input is water and the output is biological, and you're building a large amphitheatre, how many restrooms do you have to put in conjunction with that amphitheatre? A computer could conceivably be useful in arriving at a decision in this case. This does not seem to me to be in any way different from the simultaneous questions going on as to what is the output of the university and what is the input of the university, and it even seems to me that the approach to what is the input of the university, and it even seems to me that the approach to what is the output of the university could be made, at least in the beginning, on a perhaps naive and superficial level, but at least it's a beginning. Could one ask, for example, such questions as: what is the impact of a university on its society? Could one then go to a university that's been impacting a society for a long time, like Oxford, and would there be any way of evaluating what kind of impact, in terms of ideas, in terms of people, whatever you want? I read somewhere recently that one out of ten university president s is a graduate of the University of Chicago; yet the total student body of the University of Chicago is very small. Facts such as this, statistical statements such as this which might be accumulated and over a long-range period give some clue as to what we are talking about when we talk about the products of a university.

STARKWEATHER: I take it you were talking about products in the sense of specific vocations of that or some other type. You might use that manufacturing kind of analogy. I think that what education really tries to do is to produce people who, not so many capable of solving engineering problems and so many capable of solving historical problems and so on, but rather people who come out of this experience, whatever their speciality, with a kind of learning ability, an ability to acquire new skills, an ability to solve new kinds of problems as they arise. How many of us here could have predicted we'd be here discussing this particular kind of technology very many years ago: The fact is that each one of us had to switch our field, in a sense, to pick up a whole new area, to attack a new problem. We can't predict what those vocations and actual operational behaviors are going to be required twenty or thirty years from now. Therefore, I think we have to do it in terms of the ability to learn new things and the ability to solve problems that come up afresh. We have to think of what is the best kind of predictor that we can find at hand at all is____________ the capability of students in those courses, if we could point our fingers at them, which require exactly this kind of approach to new problems. I would argue against this notion of moving out into the community as it now exists in order to try to measure our product. I have some fear that was expressed a little earlier about what the department of information sciences might be trying to build as a total simulation of a university structure. If this product isn't developed in constant interaction with the administrators who are making it work right now and developed in response to what they had to have in terms of information; you know the analogy to what has occurred in some departments of education is painful. I don't like to consider that.

SNYDER: Mr. Murnin asked a question and I don't think he really got an answer. I think he asked it in the context of Jim Miller's presentation of what Cloud 9 in the future might look like, and I'd like to suggest that I don't think the answer to Mr. Murnin's question rests on the present state-of-the-art and the science of simulation. I think we ought to remember that we started with Dick Atkinson talking about youngsters facing a console and we've come now to the university as a system and the university in its larger environment. At each point, we've been raising the question about the possibilities and potentialities of something called computer technology, and quite apart from the things internal to each of those phases, I'd like to suggest that we consider that we have come to the year 1965 knowing pitifully little about things called universities and colleges. In many ways this is the darkest secret that society has had. I come from the Big Ten where I think sometimes the sitting on certain kinds of information was almost the equivalent of an international espionage system. I make the point because I think that the art and science of simulation is not the issue but rather that we have the following condition: one, that there be an administration secure enough and open enough intellectually that to say that we have a range of potentialities in this technology and that we are now willing to face questions which I think most administrations, if they face them, you know, in the privacy of the dark hours of decision-making, don't share them necessarily with faculty and students. If you look at the record, I think you'll find that many university and college administrators do not recognize that decision-making, policy-making, looking at the relationship between input and output, are questions which are susceptible to rational analysis, susceptible to application of relatively new techniques and so on. I'd just like to suggest that if you have an administration that's open and secure and if you have resources over and above the ones that are presently committed to research, teaching, and building construction, and if you have essentially a close communication, intimate day-by-day communication between the kinds of decisions and information needed in connection with those decisions that have to be made by the top, communicating with that a group of people who are committed to the slow, upward climb to Cloud 9, that somewhere along the way both the immediate kinds of things that Licklider was talking about perhaps will be reformulated and thus subject, perhaps more fruitfully to some new ideas and new technologies. In aspiring to Cloud 9, we will face, I think, questions that will begin a revolution in American higher education which I don't think yet has begun, namely to tackle the question that Dr. Hitch poses, of the difficulty of defining and measuring. I think we would recognize that logically this is certainly a difficult thing. The question I'm raising is whether that also isn't an empirical question and whether, in point of fact, we haven't pretty systematically swept under the carpet the critical questions. I certainly don't know the answer. I'm only suggesting that I think part of the response to Mr. Murnin ought to be is that there are necessary and sufficient conditions for starting now, both on Cloud 1 and Cloud 9, and that these involve not just the technology, but factors having to do with the sociology of knowledge, the psychology of knowledge processes, and the kinds of institutional traps into which maybe we all have fallen. Someday someone will have the courage to saw open a few of these doors and say as gray andas windy as it is out there, let's peer in and see what might happen.

ALDRICH: This comes back to comments Mr. Selfridge made, and I simply wanted to point up that I think if we are to move according to ideas that have been set forth here, there's got to be complete fearlessness. I'm not even suggesting fear but willingness on the part of those in administration to share with anyone in the system information at hand. This business of being privy to some information and not to others, I don't think, generates the kind of interaction between those who can move up from art to science to technology very fast. So Dick Snyder's remarks about the willingness to simply say, "Here it is in all its weakness and frailty, lack of this, that or the other thing." If there are people interested in trying to do something with it, they should be levelled with so that they at least know the base from which they're operating.

GERARD: Dick said so much of what I had in mind and said it well, that I can make my comments very brief. I threw out the realism of what we were talking about, for a very definite reason. And it has become clear in the discussion that one can do very much at the immediate present and can build up from that to very much more in the not too distant future and can expect that the rate of slimb will progressively accelerate. I remember many years ago Bavelas was asked to work out the communication network of a large institution. I don't recall whether it was a large university or an industrial institution. He made the simplest kind of imaginative approach to it. He simply went to a great many people and said, "Tell me which telephone numbers you can remember in the organization." He found out almost at once who was communicating with whom and with what degree of frequency. This is working through a great deal of complicated model-making by imaginative cuts; nonetheless, one can do this and much more elaborate things with the total resources. I do want to reemphasize the point that Licklider made. When I picked up simulation, I was deliberately thinking of the topmost level of complete analysis and understanding and not the fact that one can already do a very great deal with data banks and simple calculation and so on. I was hoping we could have a few minutes on that question of the department of information sciences that seemed to interest many people.

MILLER: Just a brief comment. I entirely support the idea that as much administrative information as possible be made public to the total community to work on. Information related to individual's salary or health record, or something like this, probably should not, and I don't think you meant that. We all seem to agree that it is possible to start with some simple simulations and get somewhere with them. If you do share the systems community, which is highly desirable, then almost all the comments you get back on the first ones will be criticism. There can be all sorts of negative criticism as to validness of ways of finding out who is talking to whom. Now you can think of ten reasons why remember telephone numbers is not a good or perfect measure. So what you will get back from the early ones from the community will be nothing but comments saying you should add this variable and that variable and the other variable in order to complicate the simulation, and then if anybody gets the idea that management is doing its planning based on this simplified simulation, they will get disturbed because actually management will have to say in return, "Well, we look at these simulations but we don't take them seriously because actually we have more complicated computer systems than this simple model and fortunately for you, we're making our decisions after looking at the simulation but considering other variables which we know intuitively."

CORRIGAN: The group has mentioned, and rightfully so, that a university is multi-dimensional in terms of its focus and its responsibilities and so forth, trying to provide top-level administrators pertinent data and presenting data. I think the important considerations are the kinds of data you need in terms of the commitment of the university. Although we talk about simulation, I think perhaps a priority factor even before that is the concept of design and what are the underlying postulates by which we design? Against this multi-dimensional picture which we're concerned with, at least we might identify a prime parameter. If we looked at a dart board, for instance, there's a bull's-eye in every increasing concentric circle. There's some priority of events. In the area of instruction, which is a prime function of the university, an underlying unit is a commitment of individual learning, and a commitment of individual learning is the development of relevant knowledges and skills to prepare an individual to participate in the culture. Underneath that is a further requirement of methods and means for producing these knowledges and skills in some predictable manner, which gets down to quality control. What kind of data do I need to be sure that learners are achieving in a quality-predictable manner? The data can be brought to you but it really is how you design to be sure that you are achieving that objective in the first place. There are methods to do this and the method of a simulation of a university in time as Jim Miller mentioned with an information center, with multiple carrels and so forth, which is a design of a facility implemented in such a way to service a community is a method of processing and transmitting data to provide knowledge and skills. But underlying it are considered design dimensions to provide the development of relevant knowledges and skills regardless of what media or methods you're employing. We can do these things now and, in instruction, if we take a design approach, a systems approach, to designing what's critical and proceed to define what data is relevant in one dimension and the second and the third, we can begin to provide the kinds of data you need in the form you need it in, in time to make the decision. I don't think you can do one without the other.

ALDRICH: Without the computer or a model or anything else to suggest to me that the time of day has come to an end, I'm prepared to make a decision. Corrigan's remarks assist me in great fashion. He brings together the things that I've been concerned about since it's my job as chairman to start and end the meeting I'm prepared to do so at this point. We are adjourned.

Thursday, November 11, 1965

EVENING SESSION

7:00 p.m.

Speaker: Charles J. Hitch

Chairman: Daniel G. Aldrich, Jr.

ALDRICH: It was suggested that I continue serving as Chairman this evening as the one to introduce our speaker. I'm delighted to do this because this provides me the first opportunity to present the newest member of the official UCI family: Dr. Charles Hitch, who became on September 1, 1965, Vice President of the University of California, Irvine, responsible for its financial affairs. I'm also particularly interested in introducing him to you, for he went to the same school I attended along the way, The University of Arizona, from which he graduated. Subsequently he did graduate work at Harvard, went as a Rhode's Scholar to Oxford, Fellow of Queen's College, and served as the editor of the Oxford Economic Review. He returned to the States where he was involved during the War, in a variety of capacities, first in the Army and subsequently in the Office of Strategic Services, and was with Averill Harriman on a lend-lease effort initially to England, subsequently in a variety of posts there, and for 13 years following 1948, until about 1961 was with the RAND Corporation, where among other things, he was chairman of their research committee. In 1961 he was appointed Assistant Secretary of Defense, and, as a consequence of his writings and his speeches and lectures since that time you are acquainted with his involvement there. He left the position as Assistant Secretary of Defense in September, 1965, and we're most delighted to bring this know-how, background, and expertise in the field of economics to the University of California. In the complex system that we are a part of, we appreciate that there will be new know-how, new sensitivity of how this complex organism might otherwise straighten out its affairs and move forward in the field of finance under the direction of Dr. Hitch. So it's my pleasure to present him to you this evening. Charles Hitch: HITCH: Dean Aldrich and Gentlemen. I am still in the process of transition from the Pentagon to campus, or more specifically, to university administration and trying to sort out the differences and similarities.

Almost everyone seems to assume that the differences are predominant. The most common greeting I hear several times a day on the average is: "You must find this quite a change from the Pentagon". On the other extreme, almost in isolation, (though not quite, because this afternoon I was joined by Leonard Rieser), who is a highly perceptive friend of mine on the Berkeley faculty who warned me on arrival in Berkeley, that, "Your occupational hazard will be thinking that your new job is precisely like the one you left. "In fact", he said, "there are significant differences. The University of California is not the Department of Defense." In spite of this friendly and well-intentioned warning, I have been impressed by how superficial many of the differences seem to be. For example, at the Pentagon, I worked for an indefatigable boss named Robert McNamara, who spent 80 hours a week in the office next door to mine. Here I work for a boss named Clark Kerr, who, it's true does part of his work at home, but is equally indefatigable, works an equally large number of hours per week and is equally hard to keep up with. And everything here has a different name. Here it's the governor rather than the president, it's the Department of Finance, rather than Bureau of the Budget, it's the state legislature rather than the Congress. And one real difference: here it's the Board of Regents. There's nothing in Defense that quite corresponds to the Board of Regents. But I'm not sure this makes my job in California any less complex. Here instead of poor military services, each fiercely jealous of its autonomy, we have nine campuses, each also more or less concerned about its autonomy. Some more concerned, like the Navy. In the Department of Defense the military services year after year would present budget requests averaging 20 to 30% more than the Secretary of Defense, the President, or the Congress were willing to approve. Here I understand campuses present budget requests which, on the average, exceed by 20 to 30% what the President, the Governor, and the legislature are willing to approve. We may be dealing here with a constant of human nature operating in large organizations. One final, most impressive similarity is an intense public interest. I almost said, an unhealthy, obsessive fascination in everything that happens in or on a University of California campus. There is the constant glare of the press, and the threat of legislative inquiry. In either environment, tugged from below from those who demand decentralization, pushed from above by those insisting on order, balance, economy, and control....surrounded by spectators, most of whom seem to be waiting to veer and throw stones.. It's obviously pretty easy to get hurt by little mistakes of commission or omission. Sometimes it almost seems by any feasible act of commission or omission. In the Pentagon I recall from time to time, as a sort of bad daydream, the experience of the Barbados brick layer, and I wouldn't be surprised if I continue to do so from time to time in University Hall. In case you forget his story, I quote from his letter as reported in the Manchester Guardian: "Respected sir", he wrote to his employer, "when I got to the building, I found that the hurricane had knocked some bricks off the top, so I rigged up a beam with a pully at the top of the building, and hoisted up a couple of barrels full of bricks. When I had fixed the building, there were a lot of bricks left over. I hoisted the barrel back up again and secured the line at the bottom, and then went up and filled the barrel with extra bricks. Then I went to the bottom and cast off the line. Unfortunately the barrel of bricks was heavier than I was, and before I knew what was happening, the barrel started up, jerking me off the ground. I decided to hang on, and half way up I met the barrel coming down and received a severe blow on the shoulder. I then continued to the top, banging my head against the beam, and getting my finger jammed in the pulley. When the barrel hit the ground, it burst its bottom, allowing all the bricks to spill out. I was heavier than the empty barrel, and so started down again at high speed. Half way down, I met the barrel coming up, and received severe injuries to my chin. When I hit the ground, I landed on the bricks, getting several painful cuts from the sharp edges. At this point, I must have lost my presence of mind, because I let go of the line. The barrel then came down, giving me another blow on the head and putting me in the hospital." The moral is: "Don't lose your presence of mind, and you may be able to keep the damage within bounds...that is, short of hospitalization."

I was deeply honored to be invited to address this dinner since I am clearly a neophyte in the affairs of universities, or have been on leave from them for so long that I need to be reinitiated and am in no sense a computer expert. I pointed out these facts to Dean Gerard in response to his invitation, suggesting that he or his computer had made an error in identifying me as the appropriate speaker, but he replied, and I have his letter here, politely, but firmly, nevertheless, come and talk on any subject you please. So I have come, but not until after quite a struggle, with the problem of a subject. One of Robert McNamara's management maxims which we were never permitted to forget, was "If you have to choose between seeming foolish, and being foolish, seem foolish." If at various times during the past five years, we have looked foolish in the Pentagon, give us the benefit of the doubt, we may simply have been seizing the less attractive horn of this dilemma. It was clear to me that if I chose to talk to this sophisticated audience on either universities or computers, let alone some combination like computers in universities, I would both appear and be foolish. So I have chosen the lesser evil. It may appear foolish to talk on a subject like Defense Management in which my audience may not be interested, but at least I will be talking on a subject about which I know something, and therefore hopefully what I say will not be foolish.

I would like to try to distill for you what I regard as the three most important lessons of our experience in managing the Defense Department during the past five years. These are in shorthand. First, the necessity for unifying substantive and financial planning. Second, the relevance and importance of economic analysis even in unlikely areas of application. And third, the tremendous potential of invention as contrasted with mere comparison in systems studies.

Let me talk first about substantive and fiscal planning. By substantive planning in the Department of Defense, I mean military planning, the planning of forces and strategy and weapon systems. I presume that the analogies in a university are academic and facilities planning. We found, when we came in in January 1961, an almost complete dichotomy between substantive and military and fiscal planning. Military planning was done by the military planners. It was done in terms of outputs of the department. It was done for five to ten years in the future, it was strictly physical, it was subject to no realistic fiscal or resource limitations. The budgetary implications were usually not even calculated. All requirements were in absolute terms: we need. Fiscal planning, in contrast was coextensive with annual budgeting. It was done by the civilian secretary and his comptroller organization; it was in terms of inputs; it extended only one year into the future. In consequence, the military or substantive planning tended to be so unrealistic that it had little impact on real world budgets. It didn't face up to the hard necessities of choice. The most important substantive military decisions were made frequently inadvertently, and unintentionally by budget reviewers in the Department of Defense, in the Bureau of the Budget, and in Congress. The rational planning of an organization requires that substance and resources be planned together so that the substance will be planned realistically, confronting hard choices in their economic aspects and so that the budget will be reduced to its appropriate subordinate role. We achieve this in Defense at least in substantial measure by devising a bridge between military planning and budgeting which we call the five-year ________structure and financial program. It was stated in output terms appropriate for military planning, and it serves as the base for military planning. It extends five to eight years in the future, it provides all the resources required by the plans relating the inputs to the outputs, and it translates the resources into feasible annual budgets, each of which has become in effect merely the financial requirements for the next annual increment of the long-range substantive plan.

Second, the importance of economic analysis, what I call economic analysis. There are many different words for it. It may be objected that I am not an objective observer on this issue to which I plead guilty. I expected to find economic analysis relevant and important, and I did so. But I happen to be right in this case, no matter how lacking in objectivity. Biased observers can be right. Lack of bias is no guarantee of vision. The basic concept of economic analysis is misleadingly simple. It is, you maximize the value of outputs minus the value of inputs. Or if you can't do that for practical reasons, you maximize the value of outputs for a given input. Or you minimize the inputs for a given output. Military experts and their journalist and legislative friends found a multiplicity of reasons why this concept, so useful in the private sector of the economy, had no relevance to the military. War, of course, is a military problem, not an economic problem. There is no substitute for experienced military judgment. It's impossible to quantify national security objectives. The dominant variables are always the intangibles. And the final clincher: "Only the best is good enough for our boys." There is, of course, a small hard kernel of truth in each of these objections, of which the best, but not all practitioners of our black art, have always been aware. The most important truth, however, is that if you set your analytic sights at a reasonable level, if you're satisfied to try to find the better solution rather than the best solution, that the economic criterion coupled with systematic quantitative analysis has thrown a flood of light on one important military problem after another. For example, on the mix of aircraft and missiles, on how much is enough in strategic retaliatory forces, on how many and what kind of naval aircraft to buy and deploy per aircraft carrier, on the trade-offs between size of forces and the ability. And many many more at all levels of decision, many of them sounding superficially like strictly military problems. How broadly this kind of analysis is applicable in other areas not generally considered part of the economy, I do not really know. I am suspicious of some of the arguments I hear against applying it to universities because these arguments have a remarkable family resemblance to the arguments against the military applications.

And the third and final lesson: The great potential of invention as opposed to mere comparison and choice between predesigned alternatives in systems studies. The history of the analysis concentrated on the question: "What is the best airlift aircraft?" Sealift was considered much too slow to be a competitor. On a very early date, the prepositioning of men and equipment or of equipment only was recognized as a competitor and was included in the analysis. Then a systems analyst working on a problem made an invention. The great problem with prepositioning is the difficulty that the real estate you acquire and the equipment you preposition there will turn out to be in the wrong country or even the wrong continent when hostilities actually threaten or break out. So the analyst thought: Why not preposition on ships? A pregnant thought. And we're now getting forward floating depots which are victory ships stocked with army equipment in the western Pacific ready to steam to any threatened area and substantially augment our airlift rapid deployment capability.

At about the same time a more straightforward design development or invention produced the roll-on-roll-off ship, the ro-ro ship, which can rapidly load and unload army vehicular equipment at even primitive ports.

Than another invention was made by an ingenious analyst who simply combined the characteristics of the forward floating depot and the ro-ro ship and developed an appropriate operational concept for the combination. This definitely made sea-lift competitive with airlift for rapid deployment in many situation. And we asked Congress last year for more specially designed ro-ros to be used as forward-floating depots. I infer from the press two weeks ago that the question of who is to design them resulted in the early retirement of the two highest ranking admirals in the Bureau of Ships. Meanwhile some design inventions stimulated by airlift analysis promises a much more efficient airlift aircraft. Most important, it permits us to combine the marked economies of a very large aircraft with a landing gear and power plant which permit operations from short primitive forward airbases. This combination promises to reduce, or perhaps even eliminate in many cases the ground line of communication in the combat theatre with substantial saving in time, troops, and equipment. As most of you know, Lockheed is starting full-scale development of such an aircraft, the C5-A, this year. The analytic problem which remains is to determine the best mix of this better sealift and this better airlift. In many situations, for example close to the shore in Southeast Asia and Korea, the ships can win on cost effectiveness criteria. In other hypothetical situations, for example, further inland, the C5-A wins. Each system has capabilities the other has not, and problems that the other has not, and different and difficult to analyze vulnerabilities to enemy action. Of course, no computer will automatically provide the answer to this problem of optimum mix, but we found that a carefully formulated computer program can give valuable insights about break-even points and regions of sensitivity.

That brings me to the end of my lessons, and I've kept to my resolve to avoid the subjects of universities and computers. At least I haven't talked about universities. Everyone knows two things about Robert McNamara. First, they know about McNamara and his whiz kids. They know that he's a strong believer in analysis to supplement judgment and experience, which is true. Second, they know about McNamara and his computers, that he's enthusiastic about the use of high-speed computers, which to the best of my observation over five years is quite false. The only two occasions on which I can recall his mentioning computers were once when he warned his staff against a general tendency to computerize data information systems prematurely, and later when he instructed us not to provide him with computer-printed tables of the five-year structure and financial program unless we could get the computer to print in lower case. I was very happy to see that you've taught your computers at Irvine to print in lower case. I'm a little sour on computers myself at this moment. Two weeks ago, two months after leaving the Pentagon, I received a notice in the mail from my old bank in Washington where I had closed my account, that they had received a check from the Army for me, for $650, which they deposited to my account. My pleasure and surprise were alloyed by the suspicion that I wouldn't be permitted to keep it. Being experienced in the ways of computers, you can guess what happened. When I left the Pentagon I was signed to a consulting agreement, mainly for the purpose of keeping my Security Clearance alive. And each month the Army Finance Office, which gets out the payroll for the OSD is supposed to be advised that I have spent 00 days consulting. Well, somehow, this got transcribed or scanned erroneously as 10 days, and the computer calculated my gross pay as $860 and made appropriate deductions to get it down to $650, searched its memory to determine what to do with it, and mailed a check to my old bank. And my old bank, also thoroughly computerized, detected nothing wrong with it, and deposited the check in my closed account. In the next chapter, I received a demand from the Army Finance Office, that I return, not just the net amount of $650 which I had received, but the gross amount of $860. If you're concerned, I did not comply.

Someone has to stand up to this kind of bullying. Let the computer find its own deductions.

Seriously, though, I have nothing against computers. Probably I will learn to love them when I get to know them better, as I intend to do. I greatly appreciate the opportunity to be with you tonight, and only regret that I have been able to spend so little time with this very impressive assembly. Thank you.

ALDRICH: Thank you, Dr. Hitch, for this delightful commentary, and I'm sure we're all happy that you chose to speak neither about the university or about computers, because this added considerably to the breadth of the information to be taken away from this conference—insights of Mr. McNamara and your experience there for five years as Assistant Secretary of Defense.

Friday, November 12

SESSION VII

9:00 a.m.

Regional and National Networks

Speaker: Robert D. Tschirgi

Chairman: Richard C. Snyder

SNYDER: Let's begin in order to maximize our time this morning. I'll try to keep track of things so, to use a technical phrase, that we maximize our efforts this morning. Leonard Rieser agreed to give us a brief oral impression of some of the main streams of yesterday afternoon's conversation, and then I will introduce our speaker of the morning, and we'll go on from there. RIESER: We heard first from Dr. Miller, who discussed the topic "Top Level Information Flow" and the techniques for consolidating institutional information into a data system which would serve the entire administrative machinery. He emphasized the entirety of it. He stressed the all-inclusive nature of the system, and the feedback that would be built into it, which would provide a dialogue among a wide sampling of university personnel. This seems to me to be a very important point. He mentioned people who at the present time, hardly talk to one another. The extensive data base would make possible many sophisticated evaluations, and particularly emphasized was the opportunity to evaluate the quality of instruction in a way that has not been done thus far. The extension to the university as a whole and to networks of universities led finally to the ideas of departments of information science of very ambitious dimension. Indeed, this grows a tie onto Cloud 9 where we sought, ethereally, to define the long-term objectives of universities and of society as a whole. We were wisely told to descend to Cloud 1, if not to earth, and find a way to get started with some realistic thinking. I think it was agreed that to achieve anything like the proposals suggested by Dr. Miller, one would have to undertake, let us say, to begin at the beginning, use the equipment we have and the level of cooperation we can get at the outset, and know that this would spring forward and finally could lead to the idealistic scheme of overall management which Dr. Miller proposed. SNYDER: Thank you very much. Before I introduce Bob Tschirgi, I would like to stress that I have no doubt whatever that at the rate he spins out ideas, there would be enough to keep us here two or three more days just on that score alone, but I'm sure he agrees with me that we want this to be a little less structured than some of the other sessions, and to the extent that you find it desirable to inject questions having to do with where we go from here. It would certainly be a shame for us to break up without doing that. It would seem that the topic "Regional and National Networks" leads us to the society-wide implications of some of the things we've been talking about and certainly does point in the direction of where we go from here. We've had an exciting and profitable time. The question of implications for future action are certainly very much on the agenda. I think those of us who have been privileged to host the conference would feel very disappointed did we not, before breaking up, get suggestions from you on this. So I want to open us up to that set of possibilities and not have us too confined. Our speaker this morning is University Dean of Planning of the University of California, and he brings to the concerns of the conference an interesting combination of past experiences. I want to cite one or two of these briefly, and then let him get on with what he wants to say. Dr. Tschirgi came to the University of California in 1953 and then become involved with higher administration in 1961 when he became an assistant to President Clark Kerr. He is Professor of

Physiology and Anatomy and has participated in the establishment of medical schools and academic plans involved with medical programs. An outstanding one in this instance was the medical study for the University of Hawaii which he worked on in 1963-64. This gives you some notion of his deep experience with education and with some of the problems that arise in connection with the relationship between how universities are organized and function and some of the intellectual objectives that we have. It would be easy on the basis of one or two items like this to forget that he is a distinguished researcher, having won the Borden award for physiological research, and I would suspect that if he were to talk about his research in any detail, we would certainly find extremely interesting linkages with the kinds of information communication problems we've been discussing. I won't describe that research but simply note that it has to do generally with the brain and with current electrical potentials in the central nervous system. The notes here that are reminiscent of the things we touched upon are clear. Without further ado let me introduce Bob Tschirgi, who will talk about regional and national networks.

TSCHIRGI: Thank you very much for that very generous introduction, which I must say is embarrassing to me because sitting right next to you is my veneered and renovated professor, you know, under whom I did all this work!

I perhaps am going to be disappointing to you because I'm not going to talk about regional and national networks in the direct sense of listing the current activities of undertaking regional and national networks. But rather, I'm going to try to build a broader context of universities, as I see them, undergoing a change-a radical change-at the present time, and see if, by examining that facet of university change, we can achieve some clearer indication of the kind of regional and national networks that would be most appropriate for the future.

I believe that at the present time we are seeing the most intensive and extensive change in university existence, certainly, at least one of the most intensive and extensive periods of change in university existence. I believe that the concept of the university is being drastically revised. The image of the university is shifting, not only to the outside society but to the university community itself. The role of the university in society is undergoing a major revolution, at least this is my belief. I will try to illustrate this point of view and see whether or not you agree with me, and see if we can fit the picture of regional and national networks into this revolution of the university.

Focusing on the question of information networks, it seems to me that we must ask: what do universities have to say to one another? And then we must ask: what do universities have to say to the nonuniversity world, and what does the nonuniversity world have to say to the university? After all, on the answers to these questions really rests the nature, extent, and urgency of information networks involving institutions of higher education. Indeed, the answers to these questions are the raison d'etre of information networks and the practical considerations of how much, of what kind and when should be determined largely by the priorities given to the answers to these questions. In order to discuss the role of communications networks in the future of higher education, it's necessary to assess the changing activities within the university, and I have categorized these activities in a particular way, not that it's the only way to categorize them, obviously, but it's one way that came to my mind and that I've found useful.

First, there is the archival function of the university. The university is a repository of knowledge. In this sense, it's like a time capsule. It just sits there and collects knowledge. The shelves groan under the increasing weight of books and the buildings get bigger under the increasing weight of books, and this is the archive of human knowledge. In addition to the library, which is the obvious, most central core of such an archival function, there are museums, there are special collections, such as pathology collections, plant collections, animal collections, and so on. All of these, I believe, fall into this archival activity of the university. The usefulness of an archive, obviously, is not in its existence alone but in what can be done with it. Consequently, the role of information networks in the archival functions of the university is perfectly obvious because the usefulness depends on the effectiveness of retrieval and dispersal of the information contained in the archives. On Cloud 1, using the library as an example, we can and are starting with automating the cataloging function and with networks for the distribution of catalogs. After all, the simplest network for the distribution of a library catalog is the mail system. We make up an extra set of cards and send it to somebody else. All right, this is a primitive one, and we can go on from there into the more elaborate electronic networks for retrieval and dispersal of catalogs. This is the Cloud 1 level of present-day technology as I understand it, and this should, of course, develop toward the Cloud 9 level which is the ultimate storage in whatever appropriate memory bank or memory form exists in the technology of the not-too-distant future, in which hopefully we can contain all human knowledge on an immediately retrievable basis from any point within the country or the world. This should be the Cloud 9 end point of this kind of development. I shan't belabor the details of how one would go about setting up such a network involved in this kind of activity because it's perfectly obvious to you and many of you here are far more familiar than I with this aspect of the question.

The second function, or rather the second activity of the university (I'm a little fearful of the word function), is education. At least many of us still believe this is a function of the university. The university can be thought of as a communication channel for temporal and spatial transmission of knowledge. At least, part of the education function can be so defined. This is an area where the university is undergoing a great change at the present time. I should have pointed out that in the archival function, the university is groaning under the rapidly increasing rate of accumulation of knowledge. In the educational area, the university is undergoing a massive increase in demand. First of all, there's a tremendous expansion of the demand for higher education from all segments of society, to the point that it is perfectly obvious that before long the bachelor's degree will have approximately the same currency as did the high school diploma not too long ago. This enormous increase in demand for higher education was brought not only by the increase in population but also by the increased percentage that want higher education, requires an optimum use of teachers and facilities. Here again, we must do everything we can to increase the effectiveness of teachers through electronic distribution technique, for example, computer-assisted learning devices, and so forth. I think one of the problems we face here is a public relations one, and perhaps more important than any of the others, particularly in such areas as computer-assisted learning. You will recall a recent unpleasantness on one of our northern campuses involving certain student discontent which was characterized by students indicating they did not want to be I.B.M. cards. They did not want to be treated simply as bits of a machine. They did not want mechanistic kinds of education. A common concept among students and faculty is that the machine is a threat to good education. We must do anything we can to undo this because it's entirely erroneous; it's completely incorrect. Quite the contrary is indeed the case. The use of electronic distribution and computer-assisted learning techniques will, I believe, increase the human interrelationships. In fact, its whole goal should be to increase human relationships in the teaching-learning process. Semi-humorously, I can see no reason for one's having no affection for one's own computer-tutor. After all, we consider it quite appropriate to love books; it's an expression we frequently use with respect to books. We have great emotional attachment to books. Actually, a book is a pretty passive kind of dull friend. About the only overt, emotional aspect of a book that I can think of, not including the information it contains, is the smell of the binding. This, by the way, seems to be one of the discontents that many librarians have over the computerization of libraries - they don't have that nice smell any more. But if we love books, why can't we love a computer? A computer is a far more reacting, more interesting kind of companion to communicate with than a book, so I'm perfectly content to consider the possibility of becoming fond of a computer. Hopefully, by the use of transistorized Mr. Chips, we will be able to have more effective, intimate, human-to-human relationships to the extent that the transistorized instructor can take over some of the aspects of instruction. Then this leaves, hopefully, the de facto instructor to relate to the student in what we consider a more useful fashion. The fact that we transmit information, image and sound, via television networks, somehow seems to connote a remoteness, a lack of intimacy in education, but actually this is exactly opposite to what is the fact. Think for a moment of the relative emotional involvement that you have in your living room with a close-up view of an actor on your television screen. Compare the emotional involvement that can easily be transmitted through this one-way operation of television to that with the remoteness of sitting in the back row of a large lecture hall while some small person down in front is droning on with a conventional lecture. So it seems to me we must continue to make the point that by using electronic techniques for dissemination of knowledge and using modern technologies of learning, this would increase the humaneness of education. It will reestablish the teacher back in the central role of communicator, which is what we want him to be. But this is going to require a lot of public relations because it is precisely contrary to the usual attitude.

Among the present experiments that are being tried relative to distribution networks of this sort, I would mention the pilot studies being done by the National Association of Educational Broadcasters. They have three pilot studies going at the present time. One is an intra-university system being established within the University of Oregon system. They have an inter-institutional pilot study being set up among the Big Ten and the University of Chicago in the Midwest, and they have a third pilot study designed to explore interconnecting facilities of all potentially useful kinds on the East coast. Perhaps Jim Miller will want to say a word or two about that later on.

A second aspect of optimizing the use of teachers and facilities, particularly facilities, is through sharing. This is a tricky one, because in order to share facilities it turns out that the sharer is unwilling to give up anything in the process of sharing. One must so structure the sharing aspect so that everybody gains and nobody loses. Thus, for example, we're perfectly content to share power through an inter-connecting grid as long as it works, as long as we get our power just as conveniently and just as immediately as though we controlled it all from some local, completely individually-owned structure. We share the telephone system as long as we are in no way inconvenienced. The critical aspect of sharing facilities must, therefore, be this one, that it be more convenient to share than not to share. Thus, for example, you can share a library. You can have a central library and you can use the mail system--that's an appropriate network. You write in a request for a book, and the book gets sent back to you. No, this is not good enough because you lose the convenience of having a library directly adjacent to you where you can get the book in much less time, so this is not an effective sharing process. It's effective, but it's not an acceptable one for the long run. We must go toward the end of sharing, whereby everybody has equally convenient access to whatever it is that's being shared.

A second enormous change in the educational function of the university is the increasing dependence of technological society on trained technicians and professionals to operate the society. This is, I think, most clearly illustrated in the problem of technical obsolescence. Instead of making a general statement about technical obsolescence with which you're all entirely familiar, I would rather provide you with a brief, in depth, statement concerning this problem in engineering, which I have extracted from a study by the Engineering Advisory Council of the University of California. This group has just finished a massive and excellent report on engineering education with proposals for engineering education in the university. Let me give you some of the results. To illustrate the enormous problem of the requirements for life-long learning for the professional man, let me report in some detail the conclusions on continuing education for the engineer as published in the Engineering Master Plan Study for the University of California recently completed by the Engineering Advisory Council. This study points out that in engineering today, the need for continuing education is particularly acute because of the very rapid technological changes taking place. Morever, the engineers' increasing social responsibility is increasing their need for continuing education in such areas as humanities, management, and economics. To be successful in any profession, the practitioner must be dedicated to a life-long pursuit of knowledge to keep up with the changing requirements of his profession. The ASEE goals of the engineering education study has classified continuing education needs as follows (and I think this is a useful one for all approaches to continuing education): (1) Upgrading a person's education. That is, a person may work toward a graduate degree to raise the level of his formal capabilities. (2) Updating a person's education, *i.e.*, a person who received a B.S. degree ten years ago may wish to take course work to make his formal education comparable to that of a person receiving a B.S. degree today. (3) Diversification to new fields. A person educated in one field may seek to obtain some formal education in another field, but not necessarily at a higher degree level. (4) Maturing of a person's education, *i.e.*, a person may add a new perspective in his own field, such as the inclusion of financial, temporal, political and social factors, but again, without raising the academic level of his education. These are the goal structures as defined by this group. Most surveys, groups, and individuals writing on the subject feel that continuing education is, first and foremost, an individual problem. However, sharing in the responsibility are the industry or the employer of engineers, of course, by providing motivation and rewards to individuals, the university and other educational institutions by recognizing continuing education as an integral part of their total educational responsibility, professional societies by providing publications, meetings, special courses, etc., and society itself, by recognizing the desirability of maintaining and using this precious resource. While recognizing the shared aspects of the problem, the report highlights the responsibilities of the university and by all means places primary emphasis on continuing education as an intense problem which deserves university attention on a par with undergraduate and graduate work. Regarding the responsibility of the individual in continuing education, two important surveys have just been completed. One covered approximately 1,500 engineering graduates of UCLA and the University of California, Berkeley, and the other covered approximately 300 University of California, Berkeley, graduates. It is significant to note in the state-wide survey that immediately upon graduation, 75% of the alumni felt their undergraduate training was adequate for their first job. At the time of submitting the questionnaire, only 50% felt that their undergraduate training was adequate for their present job--an interesting index of obsolescence, if you will. This illustrates the need the individuals feel for improved education as they move along in job responsibility. It is also important to note that a large number considered the broader aspects of education, such as organizing, planning and administration, public speaking, letter and report writing, and human relations more important and necessary to their present job than highly technical subjects such as advanced probability and statistics, advanced mathematical analysis, modern physics, and modern chemistry. Aspects of industry responsibility are illuminated by a current survey of approximately 115 companies, all members of the Western

Electronic Manufacturers Association. All companies surveyed regarded continuing education as important; over 80% considered it essential and 90% or more felt that the university should play a leading role in planning, directing and administering the program as an integral part of the university's program. Only 30% considered the present university program adequate to meet the need. In the San Francisco area, only 22% felt the present program to be adequate. Considerable support was expressed for the university packaging of new technological information and developing new teaching techniques applicable to off-campus teaching, such as television, tape teaching, teaching machines and so on - a network just begging to be born. Nearly all of the WEMA respondents felt that their engineers would participate in a well-planned program and the companies would approve four hours per week off the job, most with pay, if good grades were maintained. Most did not believe taking a leave to attend school was the proper approach, but preferred instead that continuing education be undertaken simultaneously with job responsibility. Approximately 90% indicated preference for degrees with the same standards for off-campus work as on-campus work. Most felt that if the university comes forth with well-planned, well-executed programs, industry could be expected to provide very appreciable support in terms of time off and at least partial supplementation.

The many dimensions of the continuing education problem -- the magnitude, the variety of requirements, the broader attention required for social and economic capability--all point to an inadequacy of current effort. Conferences with various faculty members, deans, extension representatives and industry personnel have shown that present efforts in continuing education fall considerably short, particularly as to an integrated plan to cope with the increased professional demand.

Dr. F. H. Harrington, President of the University of Wisconsin, has visited most of the major universities of the United States and discussed continuing education with presidents, deans and professors. He concludes that the status of continuing education in these universities is characterized by the minimum of financial support that it receives and by the fact that the faculties are not genuinely interested in the program. He found that extension programs were really regarded with hostility by a sizeable proportion of the faculties in these institutions. Many institutions have devoted a great deal of time and money to overall university planning, but in analyzing the faculty planning reports, Dr. Harrington found that only approximately one-fourth really endorse it or develop significant plans for it. It is Dr. Harrington's opinion that continuing education will not gain stature until long-range, integrated programs are developed. Need I say more about the appropriate use of networks in this enormously important changing area of university responsibility?

The third university responsibility I would mention is research. I intend to say nothing at all about networks and research. This is all again self-evident and obvious. It is entirely clear to all of the audience here that the nature of research currently being conducted increasingly requires inter-unit cooperation. First of all, the questions are becoming more and more interdisciplinary. Secondly, the facilities required are becoming more and more expensive and complex. The need for networks for information exchange is entirely obvious.

The fourth area of university function that I want to mention is public service. This is the area in which I believe the greatest revolution in the university is currently taking place. It is the growing importance of the university as a social force.The operation of a complex, technological society demands increasing technical competence and larger and larger numbers of technicians. Universities are the major reservoir of expertise necessary to government and industry at the present time. When the technological demand began to call more and more on the expertise of the universities, this was at first done on an individual basis. It still is, of course, to a large extent. We're just entering the second phase where government and industry goes to a specific individual within a university and says, "Will you please come and help with a problem?", and this person, usually--not always, then leaves the university physically and goes someplace like Washington and consults, or what have you, and then returns. This is primarily on an individual basis. The university as an institution has not been involved to any considerable extent. It began this way. Now it's changing because it obviously would need to change as government and industry begin to discover that it's more efficient and usually more effective to allow the university to utilize its resources to the best advantage to solve the problem. So the institutions or subunits within the institution-departments or, more often, institutes are being asked the question as an institution, and then they are free to use their resources in whatever is the most appropriate way to solve that question. Thus, we are institutionalizing this use of expertise within the universities more and more.

The university is more and more the driving force of technological progress through research and education. First of all, industrial competitiveness, economic competitiveness, for example, the rapid dissemination of new knowledge for economic health of a technological society is essential, so that we must have networks, if you will, by which we can rapidly get into industry, into the economy of the nation the new technologies being evolved within the university. The university is becoming a primary source of solutions for problems of social welfare. Not only is the university the source of solutions for many, health and social, of these problems, it is also the agent of education to implement those solutions. It is carrying, in this sense, a double responsibility. An example of how major is this new image of the university's role is easily seen by a paragraph which I've extracted from a Ford Foundation Committee on University and World Affairs in which they casually make this suggestion: "What is especially needed is a new organization based upon American universities and colleges but able to take into account broad national needs. It would provide a mechanism through which universities and colleges can consider together educational planning, the development and employment of educational competence in world affairs, and systematic accumulation and appraisal of growing educational experience in world affairs. It would facilitate communication for these same ends in world affairs. It would facilitate communication for these same ends with agencies of government, business and foundations in the

United States and with institutions of other nations." How massive an involvement can you propose?

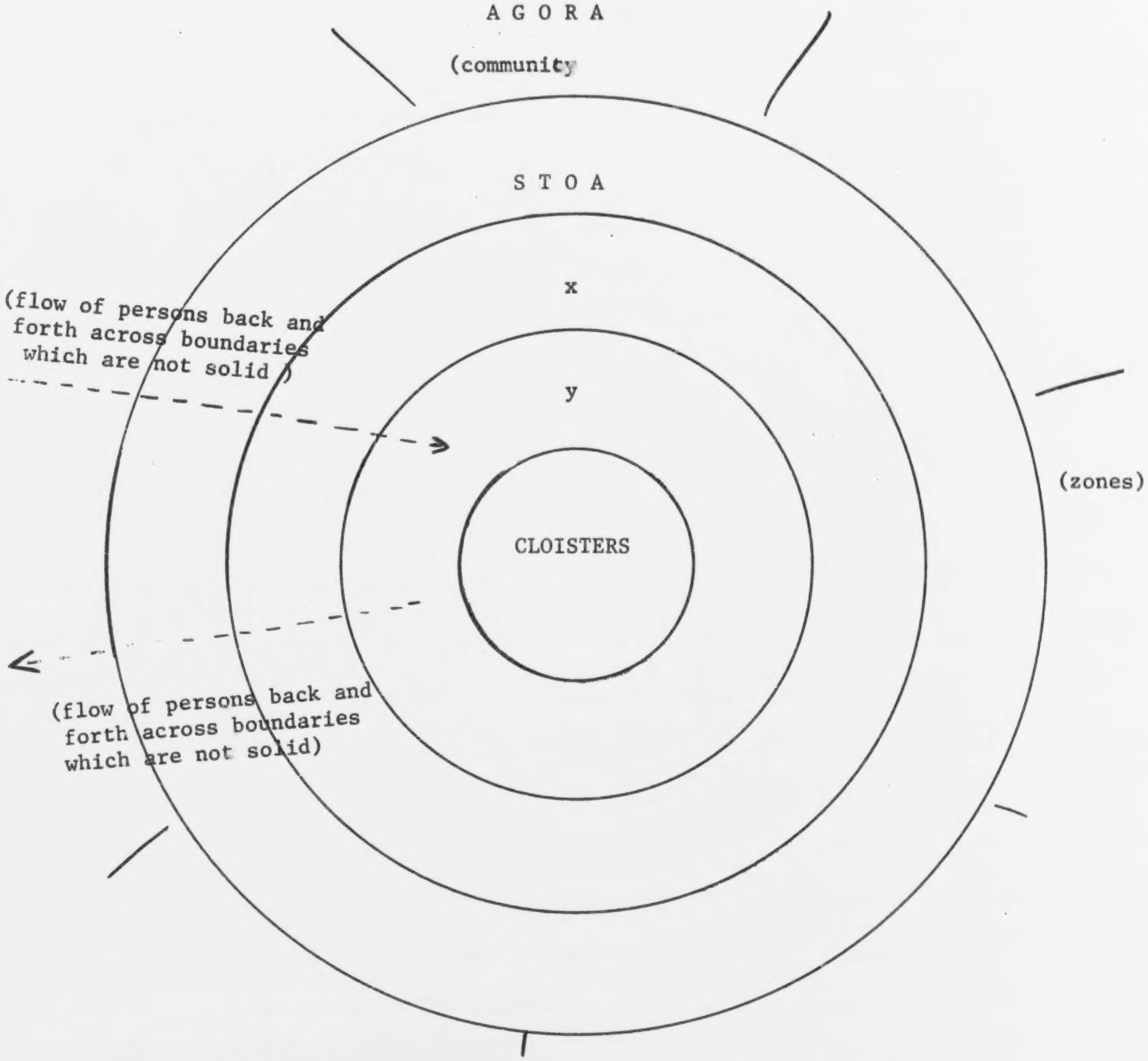
The next and, in many ways, the most significant change that I believe is happening in the universities, relative to this public service function, is one that has crept upon us, but it is no longer creeping. It's pretty obvious now, and it's time universities recognized its existence because, as yet, they have not. That is the university as executor of government. The demands of government are more and more for universities to assume an executive role, especially in areas of social welfare and technological development. Now this is something that is important, I believe, for the universities to recognize and make decisions as to their willingness to fill this role where they wish to stand in this executive function. Now this is not a new idea. Actually, this is as old as the Morrill Act; in fact, the university's role as an executive arm of the federal governmnet and the states, of course, was first assigned in 1862 by the Morrill Act, establishing this country's system of land grant colleges and universities in order to promote the liberal and practical education of the industrial classes. Those of us who are industriasts should still, no doubt, have available these universities. The Act was general in statement at that time, either by intent or simply from lack of a clearly defined purpose. However, it did make specific reference to learning in agriculture and the mechanic arts. Implementation by government of this assignment was provided a quarter of a century later through the passage of the Hatch Act. The founding of agriculture experiment stations in the land grant institutions had already taken place in some of the schools and now appropriations were available to spread their establishment to the remainder of the colleges. The granting of state as well as federal funds was encouraged. Cooperation between the colleges and the United States Department of Agriculture strengthened. The Hatch Act was followed by a series of supporting legislation, extending the research and service functions of the Agricultural Extension Division of these land grant institutions. The legislation stemmed naturally from the needs of the rural population at a time when 80% of the country's inhabitants resided outside the urban area. The type of community service offered through Agricultural Extension in its early period was tailored to the era, such as Iowa State's Seed Corn Gospel Trains. With charts, pictures, lectures, and demonstration equipment, they penetrated into the townships. Other states picked up the idea and by 1911, 71 of the gospel trains had reached nearly a million persons. This is the beginning of a kind of executive function being asked of the universities by the government, which is extending more and more. The one hundred years since the founding of the land grant institutions have witnessed the reversal from 80% rural to an urban society approaching the same percentage. The focus of federal and state governments is now widened. From the only partly solved problems of maintaining the nutritional resources flow among the world's warehouses, the range of vision has broadened to include these social enigmas for which solutions must be found if we are to proceed beyond the minimum of bread alone. The federal government has officially made demands again on its land grant institutions. It is asking for a more general translation of promoting the liberal and practical education of the industrial classes in the several pursuits and the professions in life. Rather than confining almost the whole portion of teaching efforts to the sons and daughters of citizens, it is encouraging the colleges through the higher education bill to establish community service programs. Priority is to be placed on extension and continuing education courses, conferences and seminars for community leaders, health training of nonmedical personnel, and other services specifically designed to meet the problems of urban and suburban areas. In recognition of another need, i.e., balance in a nation pursuing technical excellence through education, the role of the arts and humanities has been reinforced by federal legislation establishing a national foundations for these disciplines. The foundation bill provides for grants and fellowships to institutions in support of workshops and training and the fostering of public appreciation of the arts. The humanities, as defined in the bill, include the study of languages, literature, jurisprudence, history, archeology, the history theory, criticism, practice of art, and those aspects of the social sciences which have humanistic content and employ humanistic methods. This is indeed giving to the universities a rather enormous charter for executive involvement in the cultural development of the nation.

The contributions which institutions of higher learning can make to industry through the mechanic arts has been recognized by the passage of the State Technical Services Art. The Act permits the federal government to join the state governments, universities, and local communities in providing scientific and technical information to private industry. These services are to be channeled through the technical divisions of the universities and colleges, such as engineering and business administration units, to serve the needs of both regional and state-wide industry. The services include the analysis of regional problems, the preparation and dissemination of technical materials, the maintainance of reference services to identify scientific expertise, and the sponsoring of pertinent workshops and extension courses. As of this date, twenty of thirty-six governors have designated the state universities to run the technical services program within the state--another outstanding example of a semi-executive function being asked of the university.

Where do we go from here? What role in society should we plan our inter-connecting university networks to fulfill? This, I believe, is the broad question which we must ultimately ask. The university is losing its geographic boundaries. From the concept of a cloistered, monastic structure with real honest-to-goodness walls in which one took a kind of vow to enter and became an academic recluse, the old and, to many, still the desirable image of a university, is no longer true. The walls have crumbled. There is no longer a sharp geographic boundary across which you can say, that this is the interface between society and the university. The university has penetrated into the community and into the nation to the extent that it is now a gradual diffusion process. The university is losing its time-limited influence on life. It is exerting its influence from cradle to grave, if you wish. The extension-type programs, continuing education, should eventually reach the point where the concept that, at a particular moment in life, we enter the university, learn and then leave the university to enter society and stop learning and begin doing, must entirely disappear. We must recognize that the entire process on life's activity is a mixture of learning and doing and the university is continually involved in this process. It follows us throughout the geographic and the temporal extent of life. This is the changing face of the university.

I believe that the universities are currently in a serious dilemma of trying to utilize the organizations, the structures, the concepts of the past to fit this new group of functions and image of the present and the future, and they simply don't fit. I believe we must begin to seriously reconsider what kind of organization, what kind of intercommunication within the university, between universities, and between universities and society should exist in the light of these new functions. Let me give you some obvious examples. It has always been customary to have neat little pigeonholes in university organization by which one says, one can answer such questions as, "How many faculty members do you have? How many students do you have?" Just take those two questions, perfectly simple, straightforward questions. I propose for you that in the university as it is evolving, these are not meaningful questions. They cannot be asked. You can ask, perhaps, such things as, "How many people do you have that are listed on a particular budget who receive over 90% of their salary from that budget and who have contact

MODEL OF A UNIVERSITY


AGORA
(community
STOA
x
y
CLOISTERS
(zones)
(flow of persons back and forth across boundaries which are not solid)
(flow of persons back and forth across boundaries which are not solid)

AGORA: Social Community
STOA: Professional Schools
  Research: Applied
    Engineering
    Public policy
  Public Service:
    Advisory (only partially executive)

x : Core of human heritage
  Locus for undergraduate students
  Meeting ground of generalists

y : Advanced, in depth academic disciplines with students?" That might be a category. There will be others listed on that same budget receiving over 90% of thier salary from that budget who do not have contact, etc. The old, simple categories are no longer appropriate if we continue to try to use them, and I think we are having a lot of difficulties in attempting to use them. The same way with students. How many students do you have? Well, what do you mean? Do you mean fulltime students, and exactly how do you define fulltime students, etc.? This is the new fuzziness that is happening to universities; as universities become more and more complex and more and more imbedded in social activities, they become fuzzier and fuzzier and it is more and more difficult to define with any clarity the categories within them.

I would propose for you a new (though not new) extension of what seems to me the present direction that universities are moving. I would propose to you a kind of organization as it appears to me is emerging. It's a series of concentric circles, really. May I draw them on the board? This is really a combination of two things. It's one, what seems to me a sort of emerging patterns that is occurring at the present time and secondly, it happens to be something that I have a bias toward, so it combines two things. The university as a series of circles. This is the community, the local community, nation and the world. That extends out that way. Although I've drawn lines, they're not lines, they're zones. This is a continuous striation from one area into another area, so do not misinterpret this as sharp interfaces. There are no sharp interfaces in the university of the future, as I see it. The only names I've come up with for part of these so far are--I call this the cloisters and this the agora and this the stoa. This is just Y and X. The concept is that in the outside, the agora area is the area of maximum instrusion, maximum diffusion between the university and the community. In this area, the educational function is largely that of continuing education, of open-circuit television, of refresher courses, of cultural relationships between the cultural activities that are shared with the community and the so-called university. Research in this area is the social laboratory, the youth of the community, etc. The public service aspect of this region of the university would be to the extent that the university is the executive, has executive functions. They would be largely found in this region-social welfare programs, health, education and welfare proposals that now exist in respect to centers for heart disease, cancer, and strokes, things like that could all be executed through this peripheral series of activities for people in this area of the university. In the stoa would be the professional schools primarily. These would be the schools of medicine, of law, of administration, and so on. Here the education is largely professional-type education. To the extent that one can make a distinction between applied and basic research, the research in this stoa area is more applied than anything else, the engineering kind of approach. The public policy studies, and so on, would be found in this ring. The public service function of this area would be largely advisory and only to a literally small extent executive. This would be the primary source of advisory expertise. Inside that would be the core of human heritage. This is where, for example, undergraduate students would begin. This is the concept of the undergraduate students having a local. Here is the area in education of undergraduate students, if you will, in the area of research and higher educational activities. This is the breeding ground of generals, of people whose concern is more in breadth than in depth, who are more interested in interrelationships, in coordinative concepts, syntheses, than they are in going into depth in a specific detailed area. The public service functions would be less all across the board here than here, for example. Still from here would come advisory public services, but that would be of less significance than it is in this outer area. Y is the more conventional, in depth, advanced academic disciplines. These would be the areas in which graduate studies would be primarily carried on by graduate students who are choosing to go into a more traditional discipline and go into it in depth, such as physics, mathematics, or chemistry, and so on, and who are not primarily interested in the broad, interdisciplinary approach to education. Research of the conventional, in depth, kind would be thought of as existing in this circumference. And finally, the cloisters, and I bring you the cloisters only to point out that I think we ought to have this kind of structure if for no other reason than to preserve the cloisters, because I propose that the cloisters are disappearing from our universities at the present time. We have no more havens to which we can repair those people, and there definitely are those people, who can make their major contributions to society only when they are prevented from being bombarded by the exigencies of the economic world, even prevented from being bombarded by our own administrations. Only under these circumstances can they really produce what it is that they have to give, and we must provide for them a Grove of Academia in which they can do this. It is disappearing from our universities at the present time, let's face it. It absolutely is, I'm proposing it must not. This is a precious, precious element and we must provide this. If you want to think of it as a cotton-batting environment, fine, we must provide this for them. I don't care how we provide it, we ought to provide it. If it means building stone walls with moats around them and drawbridges and portcullises, okay, let's build stonewalls with moats and drawbridges and portcullises, but somehow let us provide for these people this kind of retreat. This I would propose is the cloisters and in here are come-and-go people. Now remember, as I said, these are not sharp boundaries nor is there any fixation of any of these. The important difference between this concept of the university and the more conventional one is that this represents a steady state situation, not a structured situation. People are flowing continually back and forth as their interests change, as their period of life dictates that they're more desirous of doing one thing than another; they move from place to place. There is a continuous flux in and around and out and through this thing. It is the overall steady state situation which represents the continuation of the outline.

I will stop at this point, I believe, because I hope I've opened up enough possibilities for discussion. I haven't talked about networks, the focus of this morning. I hope what I have done is to provide a framework within which we can consider networks. For example, if we were to accept anything like this as a model (or you can come up with any kind of model you want), but first if we have a model such as this kind, and if we look at the interaction of the university with itself, with other universities, and with society, then, perhaps somehow along the lines that I have outlined--all right. What does this mean in terms of information flow? What kind of information flows ought to exist within this structure? What kind of information flows ought to exist between this structure and others like it, and this structure and society? Thank you.

SNYDER: Thank you very much. I would like to propose that we start our question period immediately going. LAMBE: Well, I find this map that Bob Tschirgi has drawn for us a very intriging one. It classifies functions and the personnel of the university. Bob, you seem to worry that cloisters are disappearing and I would have thought, offhand, that the growth of specialized institutes on university campuses and in conjunction with them is, in some measure, an attempt to keep that kind of freedom. I presume that, since we know that institutes of this nature have grown rapidly and are growing rapidly, you must reject that for some reason as a proper manifestation of the cloister. TSCHIRGI: No, I'm sorry. In the interest of brevity, I did not elaborate. I would propose that they're disappearing only from the point of view that these are real honest efforts, and some of them work fairly well, and I would foresee this cloister perhaps as being a cluster of such institutes, as a matter of fact. The Stanford-Palo Alto Institute or the Institute for Advanced Study at Princeton, are examples which seem to be working fairly well. They indicate one reason that I think there is a great need for that sort of thing. All I would say is that many of them that I've looked into have been rather unsuccessful in this particular end. They may have been successful in doing something, but they weren't very successful in becoming a retreat, so to speak. A few have been, but many have not, and the main reason that it seems they have failed is because they were not buffered well enough, either from their own administration or from the economic pressures of the outside world. That's the way I would like to see it go, but I think we need to make a special effort to buffer these things. MILLER: Well, this is a most stimulating and thoughtful presentation, and it seems to me that this is a sort of simulation of the university that you've drawn up. It shows the purpose of the boundaries between the university and the community, and I think this is appropriate. About the cloister, though, I think that it is not walls or portcullisses that are going to make the cloister but a change in the individual situation of the scholars that would like to be in it, because I'm convinced that a scholar is very, very much a hermit. If he doesn't want, in his own lifetime to have his own thinking communicated and put effectively to the society. There are exceptions we can all think of. I think this sort of completely inwardly directed man is perhaps more a product of other ages than of the present age or the present society, which is a highly extroverted society. There are two problems, the one of the very rapidly increasing population, the other the competing information, so that if you develop highly specialized information of any sort in the cloister, you become increasingly concerned as time goes by that unless you go out and fight for your forum, you're not going to have your ideas have impact on the society. There is a severe danger that these concepts will be lost in the flood of other information. This gnaws upon the man who would prefer to remain in the cloister because he does not have conviction that present forms of publication will stir up sufficient reaction to the academic community to assure any form of impact or immortality. And so he looks toward various techniques, various contacts with government, going out and giving lectures, traveling around to conferences and other things of this sort in order to overcome a problem which is relatively new, and that is you can't personally know, as was true thirty years ago, a majority of the significant figures in your specialty. You cannot be assured that your publications will be read by most other people who are extraordinarily busy and most of whom you realize are skimming through the literature. So, something new has happened in recent years that in addition to having the ideas, you have to fight for their survival by these techniques, all of which involve external processes of communication outside the walls of the cloister. Now, if it were possible for the communication technologies of these networks that your're talking about to accomplish this in some way without the effort of the individual to go out and strive and travel around the country and the world in order to get the forum, I think it might well be that many of these people would be satisfied and content to remain within the walls of the central unit there. I think that this should be one of the purposes of thinking about communication science, how this can be accomplished by our networks. Now perhaps my analysis is simply an analysis of my own personal dilemma and those of my associates that I have known, but suspect it is not. I suspect it's more general. I'd like reactions.

ALDRICH: I'd like to pick up just where Jim Miller left off and comment in a little bit different terms. I've always felt that within the university, we must afford the cloister and by this I mean that there are those with no desire, who, by way of personality or characteristics of one kind or another, are not stimulated by nor do they respond to this business of communicating that which they are working with others, but someone in the system has to do this job for them if the support is going to be available to them to carry out that which they are uniquely qualified to do. I look upon this as one of the responsibilities of administration. You put it in the terms of information and communication science network. There are those who, on the other hand, as a consequence of communicating, derive from the reaction obtained stimulus and ideas that enable them to push on further. Others don't. They're bothered by the pressure from outside the university or outside the activity within the university. In the case of developing a new campus, you hope to have among those present, those who can communicate with the outside, and those, on the other hand, who are willing to spend their time simply banging away in the cloisters, as Bob has suggested. But some way or other, we've got to produce the communication that enables them to continue to do so.

GERARD: As Bob built his dramatic picture of protecting these cloistered creators, my first thought as he was talking was that all you have to do is not give them telephones and perhaps mail; then, of course, nobody's going to come and bother them. Jim says, well, at least, let's avoid the man having to go out into the world for his communication on things he needs and bring it in through a terminal, and Dan picks up on some of the things within the university and the psychological factors. I think the real problem is deeper than any of these, and I don't see a solution to it, but it does cut right at the roots of much of the discussion we've had this week. The primary problem is that mankind collectively has created such a plethora, such an ocean, of information of relevance. Shakespeare, knowing the English language and having interacted with human beings for part of his life, could perhaps retire, or Milton, and out of his own internal creativity could produce these tremendous works of art or somebody doing a picture. And this can go on more or less indefinitely, but in the other fields where the necessary information is so critical to one's creative thinking, particularly in the sciences and more and more in the social sciences, it is the mere flood of information that the creator must interact with that is impinging upon his cloistered existence. I think the conflict is an information problem between time to manipulate information internally and still have access to relevant parts of it externally. I think this comes right back to the center of the whole issue we have been dealing with. How can we make information available? How can we help in the selectivity? How can we give the maximum predigestion and all this? This comes right back to the network, to storage, and the data bank problem that we started with. I don't see a solution in terms of buildings or simple devices. STARKWEATHER: I'm concerned about what we were talking of in terms of the central cloister--the kinds of people we are trying to protect. Let me describe what I see as two extreme types of personalities. On the one hand, extreme type number one, a person who in communications terms receives but doesn't transmit, a person who might be characterized like a sponge, constantly reading, listening, absorbing. This sponge, somehow, seldom gets squeezed. If this person is not quite such an extreme type but tends in this direction strongly, he might produce some occasionally useful work like reviews of a field or something of this sort, where really he's not adding innovation or information but he's putting things in order. Take the extreme case of a person who transmits but doesn't receive. In the ultra-extreme, both these are very irritating people to deal with. The kind of person who transmits but never hears anything you say to him is, of course, always an irritating type to deal with, and yet it's a person who tends in this direction who is the kind we are concerned about here in terms of buffering and protection. If we think that this person who tends more to transmit and less to receive is productive in what he transmits, then we want to find ways to buffer him. Now I'd like to put this buffering notion in other terms and say what I think is important here is control of the input and maybe make a principle out of it that a good communications network should, as much as possible, give the user of it control over the input. That is, what is irritating to many of us about communications networks we use all the time is that the telephone can ring with no control on our part. Mention was made that to protect a man, you don't give him a telephone and yet you'd like him to have an available instrument with which he could make queries where he could control the input, where he can, at one time or another, allow messages to come in. And, therefore, it seems to me that the notion of finding ways that this person who is buffered has control over his input to some extent--the kind of buffering that would be useful in terms of a communications network. TSCHIRGI: Could I just make a quick comment about that? I'm sorry so much emphasis has gotten placed on the cloister. Maybe it's because we all really in our heart of hearts want a cloister. Let me also reemphasize that I agree entirely with what you say, John, of course, but let me also reemphasize that this is a steady state situation, and I suspect that there are, perhaps, the majority of us in the academic world at some time in our lives want the cloister, but only for a period. Then we want to leave it and go out and do something else. STARKWEATHER: That's why I think this recasting in terms of control is important because you can turn the gain down and you can have some measure of how much you want to be buffered at this particular time and you can move in or out in this measure. GERARD: There is an example of this at the Center for Advanced Study in the Behavioral Sciences at Stanford. The scholars' cubicles are built without telephones. There is one telephone in each row and a buzzer in each room. When somebody wants you, it buzzes, and you have the choice of paying attention to it or not. To the best of my knowledge, during the entire first year, which is all my experience encompasses, nobody ever ignored the buzzer. SHARP: Can I respond to this? I'd like to respond to Mr. Starkweather's comments. It involves the dissemination of information systems. It would be nice, I think, to have a variable gain on these systems, too, because there are times, I think, in each of our lives when we're very deeply embroiled intensively in one project and we really don't want to be disturbed for something that doesn't pretty directly relate to that project or have a very high priority. Other times when we're trying to cast about for ideas or when we really are not working intensively, we would perhaps like a flood of new ideas to reach us, and so if we could adjust the gain of the system in accordance with our mood at the time, we would also have another type of control.

GOODMAN: There are certain aspects of these problems that depress me. Although it's nice to be able to adjust the gain, it's also nice to have systems that help protect us from ourselves, where somebody else is fiddling with the gain for us. Essentially, I think we can get mixed up about the physical isolation of this. The most isolated, cloistered people I know live very close to the center of large, metropolitan districts. It's much easier to be an individual, alone, and have peace and quiet in the most hurly-burly type downtown area where there's kind of a cloistering through resignation. You know, you can't deal with all these people. If you expect cloistering in a kind of spin-off, isolated environment, I don't think you'll find it. I've never found the branch campus of the University as cloistered as the main campus. The number and range of responses you have to make sometimes goes up as you get into a smaller organization or physically cloistered environment because you're called on to do things you wouldn't have had to do if you had remained in the main stream. Essentially, there is discussion, I think, of flooding a person with information rather than censoring it from him and he may find a cloistered environment right at the heart--in the sort of calm in the eye of the hurricane. I don't know the impact of this but oddly enough, you find the cloister in the least likely places. FLOOD: Well, I want to go back to an earlier part of Bob's remarks, about the crumbling walls and the thoughtful bit about the desirability that walls will crumble faster and perhaps a means for doing this would be through use of the networks. In order to make my point, I'd like to illustrate using the MAC time-sharing system simply to be sure we have a concrete thing rather than a Cloud 9 example, and then extrapolations from that can be dangerous or safe, depending on who does them. I'd like to come back to something Bob Corrigan said a day or two ago. I had not heard about the college in Union Lake, Michigan, and so what I say may not be a perfectly accurate statement, but I was greatly impressed with what he said because as I understand it, it's a new campus, which is student-directed, and when I made my Cloud 9 remarks the first day of the meeting, they just sort of developed what I had in my mind. I didn't know it existed. The point I am making is this. I have a feeling that the system that Bob described, in terms of lecturers and classrooms and walls should be rapidly on its way out in the decade and we should tend more toward the student-directed kind of college. Now the point is that, further, Bob said that they paid 30% on physical facility, I believe, and I just can't quite see why in a few years we'd even want that physical facility in the sense that a student might as well sit in his dormitory as be in a carrel, or I might say two carrels, someone said that he might not study in the dorm. Well, this is a horrible thought, but the fact is you can always have a system wake him up at 3:00 in the morning and he could study for seven hours. So there are new kinds of capabilities when you get things on a communications network with processing capabilities that I think will make the walls crumble very much faster. Now let me come to my MAC example. I was asking Dick Atkinson yesterday how could I get Coursewriters to play with. We discussed that, and it's the usual thing. You can get a copy if you get the right people to let you, and you can do some reprogramming of MAC and do as Oliver Selfridge does, just program during the week, and then I could sit down and try to use it. That's terribly primitive in today's technology. If the proposed Coursewriter were on the MAC system, and by some incident Dick learned that somebody at M.I.T. had the Coursewriter there, then that's all he needs to know, because if the man that made the system public (and there's a routine for doing that at his console wherever he is), then it's immediately available to Dick at his console and it's published immediately. So the point I want to make is I think we can make the walls crumble very fast through connecting many universities and other kinds of organizations together with this new communication and publication facility. The central thing is the publication facility because immediately when a man has something working, for example, at my console at Ann Arbor, I can send a message in the MAC system and mark it URGENT if I want. The next time Dick sits down to his console at Stanford, or anybody anywhere, if I addressed the message to him, he reads that file and it tells him that there is something very exciting in my file marked so-and-so. He can then turn to it and exercise it without any further work, operating that program, no matter how complicated. It could teach him biochemistry, like the one here in the University of California at Irvine. Licklider has discussed this in writing. He is perhaps responsible for the name "on-line intellectual community". I personally think we have something which will help to make the walls crumble in all sorts of ways. Finally, regarding cloisters, it seems to me that there is another very fundamental thing that is happening. In science and technology, for example, as Jim Miller said, if you seek immortality or dollars through invention or copyright or recognition in university administration, or immortality, the old idea of having an idea, is pretty much out of date now. First of all, it's probably happening in a dozen other places at the same time or within a day or so. I think that this new medium of communication and publication, because of the rapidity with which it works could recapture a little bit of that if it's desirable, and I'm not sure it's desirable. But I think we have some urgent need for this new form of communication and publication of inventing new ways to replace old ideas like copyright, conventional salary increase and so forth, and I predict that they'll happen. I don't know what they'll be like but I'll be amazed if, during the next ten years, all sorts of people don't find all sorts of new ways to give credit for good work in these new forms of publication. LICKLIDER: I'd like to connect with the phrase and concept "on-line intellectual community", and incidently, I think the phrase is Carl Overhage's.

Another phrase and concept is suggested here, the on-line cloister. I would like to point out that they're quite compatible. They're just two aspects of the same thing and they are, because if it's true that our communications will become computer-based, that they will take place through the agency of a computer and information network, then they will be mediated by, buffered by, a set of programs which somehow come to express our individual personalities and control the interaction between our own work and our own programs and our own models and the computer and the experiments we conduct through the computer, control the interaction between those things and the outside world. Now this control can become quite dynamic, quite sophisticated. It can respect those periods in which we want the cloister aspect of the intellectual life and then respect those in which we want the intercommunication. I think this has some bearing on the concept of selective dissemination of information, on the whole notion of dissemination. Dissemination should not be so forceful that it comes through with a loud, raucous buzz whenever there is something that approaches our attention, but there should be the very discreet nudging which should be supervised by some agency that has an understanding of what our real needs are so that it will not get through unless it's relevant, not just to our long-term interest but to our immediate working purpose. SNYDER: Jim, is this a good time for you to say something about the Interuniversity Communications Council (EDUCOM) since it is a new and concrete kind of thing which relates to Project MAC and other things? MILLER: Yes, I don't think a great deal needs to be said to this group because most people here know something about it. There are currently

22 universities which are members of this new nonprofit organization. It is supported by a grant of $750,000 for five years from the Kellogg Foundation. There are over a hundred campuses in these 22 universities, including the 58 campuses of the State University of New York, and the 9 campuses of the University of California. The obvious desirability of combining resources in the communications field led to the development of this program. The organization will operate through the Council in which each member insitution has one seat and vote, and the Board of Trustees. But more significantly the operations will be carried out through intrauniversity committees, so called "INTRACOM" committees which each university is encouraged to establish. One of the more difficult problems we've had is trying to determine exactly what the role of these committees should be in individual campus universities and in multi-campus universities. The organization is certainly not going to be as effective as it might unless the universities take steps to organize themselves into some sort of internal or local network which will be multi-media in character so that the potential trade-off between the different media can be carefully investigated by those committees. EDUCOM will make strong efforts and there are plans well afoot now to make direct contributions to the universities that will make it worth their paying $250 a year annual fees and sparing the time of some of their staff to carry out these functions. But, on the other hand, the universities need to do something, too. In most of the universities the different media are not talking effectively together. They have been so limited by the concepts of their medium that they have simply thought of information processing in the more general sense. The first thing is to get the concept of

the nervous system for the total society, the network spreading throughout Bob's picture into the minds of the officials and faculty and students of the universities, I think, and for them to recognize what their primary activities and goals are in this more generalized concept. This in itself constitutes an educational process. Secondly, it's important to get them objective information about the nature of the technologies and to eliminate the natural animal fear that seems to be engendered by first contact with these robots. Carle Hodge, a science writer on our staff, will be preparing periodical publications which we hope will go, not just to deans and administrators, but to all the faculty members of these universities so that they can become informed about the technologies and their potential. His effort will be to make this interesting, clear and explicit, so that the humanistic as well as the scientific and applied aspects of these technologies will be pointed up. There will be very precise statements made of what an individual faculty member could do in order to take advantage of these new developments in his own particular situation. There are going to be six or seven inter-university task forces through which the technical activity will be carried on and I think it is appropriate that the first one that has become really active is the Network Task Force on Information Networks, because network is the essence of the concept. This task force shortly will provide a proposal or set of proposals for national network projects on a trial basis, where a few selected universities plus perhaps some governmental and private institutions would be hitched together in order to experiment with its potential. This is going to be quite an expensive undertaking. Up to now, EDUCOM has carefully avoided getting entangled either with industry or with government, by having private foundation support. When you get into something this massive, it'll either have to be some large private foundation or some government agency or group of government agencies that will fund this experiment. The universities themselves clearly would not have the funds to be able to do this.

Now while this technology is being investigated and this proposal written, a series of other task forces are being set up. There is one on the local terminal and the multiple software, as it were. That is, education systems like programmed instruction, television, radio and related educational technologies. It's my belief that it's necessary to improve as rapidly as we can this man-machine interface and to make available remote and immediate and rapid access. For example, in the field of educational television, I think the concept of the time-shared remote terminals should also be applied. We must develop hardware which makes it possible for a student on demand to get a television lecture, stop it, reverse it, and to manipulate that information. The situation we have now is that you get up at 6 o'clock in the morning to get Russian five days a week on educational T.V.. If you happen to oversleep or be out of town one day, you've lost all the passive conjugations or something like that. I think the concept of the development of small units of instruction that Ed Lambe has been talking about also fits into the interests of this task force and how it is possible to maintain the quality and update it. Perhaps we can use professional organizations like American Economic Society or the American Psychological Society to help the university develop programs.

The third task force deals with the copyright problem which is inherent in legal use of networks. Congress is discussing changes in copyright law. Publishers have views which in some way appear to differ from those which many universities have, and I personally believe there is a perfectly rational resolution that can be made whereby you maintain the individual enterprise of authors, including professors in universities, which is essential to motivate them in our society, and on the other hand, you get unlimited, unrestricted access to the information, not free, financially, but either paying certain charges per terminal for copyrights into a general pool or by sampling the utilization of documents or other things. There will also be concern with the automation of libraries and the backing up of local collections with what I think we all hope ultimately will be full-text storage. How rapidly this can come is a technical problem. How much should be in the local collection and how much in a centralized collection is an operations research problem of some magnitude, but the potential of having the full corpus of knowledge available anywhere in the country can well mean increased dispersion of the college into the community. I don't think we should neglect secondary education or industrial needs for information as well. Once the network exists, operated under such auspices, there is no reason why every organization in the country should not be able to plug into it. The next of the task forces deals with continuing education. There's been discussion of this today. The fundamental problem is that the individual moves frequently, away from the place where he was trained and out of any organizational structure into private practice of some sort.

In the past he has been accepted as a second-class citizen if he comes back to the university and also he feels separated from the organizational affiliations that he had previously. A network is an obvious solution to this problem in which he can plug into it anywhere he wants--his office or at home. If you need confidentiality, for example, let's say in the field of medicine, scrambling methods are available in order to make it fundamentally a closed-circuit type of transmission.

There will also be a task force on the applications of computers to clinical care of patients. Many universities and medical schools have their own hospitals and yet this is another example of Bob's vague boundary between the university and the society. These techniques are equally applicable to the nonuniversity affiliated hospitals and certainly will be used by them.

A task force on precollegiate education which indicates the belief by the Board of Trustees that the universities perhaps have some responsibility to elementary and secondary education. Rather than having an occasional professor of education help a school system with upgrading its curriculum or updating it, perhaps there should be systematic reevaluation of progressions of programmed instruction from kindergarten right on up whereby the student can proceed at his own rate and quality evaluations be made which determine where his formal education stops, whether he can go to junior college, or college or graduate school or whatever it may be. This is a continuous process, in other words. You might say two columns coming up that point at the university, the precollegiate and the postcollegiate education.

Finally, there are the sorts of things we discussed yesterday-university management. We're getting more and more requests from our individual participant universities to be able to take advantage rapidly of things like Dr. Blakesley was talking about. These are available and they can concretely help the universities save money and time, and so we very possibly go into this area as well.

I have two or three final comments. One, that it seems to me it's impossible to get involved in this sort of situation without becoming broader than you want to be or broader than your capabilities. It's extraordinarily difficult to restrict the range of your activities because you are essentially planning to grow a nervous system for the educational community. We have gotten letters from South America and England as to how they get into the system. It makes you tired to read the letters and think of the implications. It has been suggested that Telstar might be used for this particular activity. But more than that, within our own country, there are so many appropriate things to do. The universities are having so many demands, as Bob pointed out, that you could justify an expansion in almost any direction. I think our first task is to pick a delimited project which has enough scope, presumably geographic, which is one of the most dramatic aspects of the network concept, so that it can demonstrate the feasibility of an expansion of this sort and does enough varied things so that perhaps different media and different types of institutions get involved. But other forms of restrictions will have to be made certainly, on the first phase of such a development until its feasibility is clear to all. It's going to be expensive enough to try to do that. The network is a central idea, but each of the other task forces are certainly going to have to feed into the development of the plan in terms of their own particular needs, whether they be precollegiate or continuing education or clinical application and so on. I can see a sort of round robin feedback. In terms of discussion today I think we are going to have to face pretty quickly how we're going to deal with public reaction, and I was particularly interested in John Starkweather's comments. In talking to people about networks I've found that one thing that frightens them is the fact that they were taught by their mothers when they were very young to answer the telephone. Why are you standing there? Why don't you answer the phone, it's ringing, is something that's in the past of all of us and people are frightened because of this. They realize that the Library of Congress can be on the other side of the telephone and the first fear is related to the invasion of privacy by this peculiar electronic brain, and so on. Somehow we have to get over that idea. There can be stop buttons and, if necessary, you can pull out the plug of computers and they stop operating. The forms of sophisticated handling of information whereby they can provide you with any degree of intercontact with information you want and yet any degree of solitude you want certainly have not been emphasized, and that sort of thinking, I believe, has to come early into the planning of these networks. In our society today we are seeing busy executives going around acting as if they are open to the whole world because this is the extroverted expectations of our society. You can't really have a conference like this in a home base without having the people who live at home go in and out of it all the time. It's just very hard to be in town (whatever is technically considered in town), and not be available. Therefore, conference centers have to be far enough away so that you can say you're out of town, so that people don't expect you to get back; otherwise, we are forced somehow in our society to appear to be open to human communications through the ordinary human network. I talked to Jack Peltason yesterday. It happens that I have spoken here twice and both times he's come in half way or two thirds through my talk. It was very undiplomatic of me to say this. I said that sometime I was going to give the end of my talk at the beginning so he could hear it and vice versa. It was undiplomatic because he didn't realize that I have thought about this enough that I'm no longer concerned about people walking in and out on my talks because I'm aware of the sort of dilemma that a Vice-Chancellor is in. He has to do that sort of thing. He, of course, responded politely and aplogized which, as far as I was concerned, he had no need to do. But somehow we need to think these problems through enough so that the need of the busy individual to appear polite and to apologize for things he can't possibly do in terms of overload is handled. I think this is going to require a fundamental restructioning of our concept of the society around the network. TSCHIRGI: I want to make only one comment. In discussing functions of the university--I refrained from making any statements about priorities with respect to network establishment, hoping that it would come up as part of the discussion. Jim Miller has now opened that door and I would like to comment that of the functions, at least as I have outlined them here, I would put top priority on the archival function at the present time just because that's the one it seems to me we're in most danger of being smothered under. They're all going to smother us if we don't solve them in some way or another, admittedly, but somehow this one impresses me as being the most urgent right at the moment, so that if I had to say, if we had only limited resources, what should we try to solve first by these technologies, I think I would put it on the archival function and its consequence, obviously the distribution of the information. KOPSTEIN: I want to raise a point here which, it seems to me, was not covered by Jim Miller or one that seems to be hidden in all this and I think that it's an important one. It is certainly true that we can pull out the plug and this is sort of a very comforting thought, that we should shut off this monster automaton by simply pulling the plug, but this is only insofar as we are aware of what it's doing to us. Now if we think in terms of such things as computer-aided instruction, particularly in a later phase of development where, hopefully, it has reached a high degree of effectiveness, and if we think further that this sort of thing is not necessarily limited to the modification of strictly cognitive behaviors but can also affect noncognitive behaviors, attitudinal structures and so forth, and if we further think of the fifth function that has been outlined for the university, namely that as an executive arm of the government in modifying and shaping society, culturally, then think of this existing in a society other than our own in other times than our own in which you have a less democratically-minded government. The crux of the point is: who will control all this? Where will the control and regulation of this total network rest? Can it ever get into the hands of the less than benevolent governments which might use this for various purposes to control the society as, let's say, Hitler and Germany? Have you ever thought about the dangers of this and to what extent we must protect ourselves and build safeguards against such a use into the system? LAMBE: Well, I'm delighted that Jim Miller said what he did about EDUCOM because it seems to me that from the operational point of view it's exceedingly important to the subject that we've been discussing here this week. What I would like to raise, even sharpen as far as possible, is the question: is there

something that we identify here from our discussions, which as an immediate result of this conference can get carried along one step further. It seems to me that the interaction has been much too exciting to in some way let that opportunity pass. A number of things occur to me, some rather small things, and some somewhat more major. Just let me take two of them. One is the fact that I'm very much conscious that in some way the clustering faculty, or the cloister if you like, is not well represented. It's well represented in a certain way but most of the people here function in other ways in the university and it's perfectly clear that, if we're to make progress, the great numbers of our faculty members who have never heard any kind of discussion like this and who tend generally to be somewhat negative when they do hear it have to get involved. To mention only one thing, the factor of 200 to one in terms of the number of faculty hours that would be spent compared to the amount of time a student would have put into an instructional sequence for computer-assisted instruction. In that connection it strikes me that the kind of striation that you laid out for EDUCOM's activities does not well match into the problem of getting the university faculty involved in these considerations. Should this conference, for example, consider recommending Jim a task force on communication about these subjects? I don't know if that's a good mechanism or not, but that's one kind of thing.
On quite another level there is just the simple business of coherent exchange or progress in small matters. If we get a bit of instructional material that works in our system, we want to be sure that others know about it and can use it. We want to be sure that somehow

the things we do, in little details of that investment, don't ultimately preclude sort of an exchange at this time. That's on an entirely different level, I recognize, and yet it seems to me that there are possibly suggestions that we could make that go to this specific kind of operational problem. LICKLIDER: First, the dedicated cloister-dwellers cannot be represented at conferences. Dr. Tschirgi gave high priority to the archival function of the network, and this focused my attention on the fact that in one conception, the network embraces many different communications media, many forms, many formats, all the way from mail and the academic equivalent of the diplomatic pouch to the electronic signals and the coaxial cables and microwave lengths. However, a lot of the archival function concerns objects, maybe large ones and maybe animals, which don't fit neatly into diplomatic pouches and so on. I would just call attention to the fact that the technology that developed things and to which many of us look for solutions is least geared to a considerable part of the archival function. So let me ask: would you separate the museum part from the library part of the archival function? If so, then we could concentrate on that which can be handled by available technologies and then, I would say that in the minds of some of us, at least, one of the areas that calls for some kind of a solution is the area that does need fairly wide-band channels. Communication of computer programs, programs for computer-assisted instruction, learning, teaching, the development of a coherent community that deals with advanced things technologically is in a fix, but I think it's not right to focus the network wholly or perhaps mainly on those things because the economic factors are heavily limited there. There seems to be a broad area which might go as far as facsimile communication, where the transmission of television material at night when most of the lengths are quiet anyway, perhaps even for individual consumption the next day, as Jim was suggesting, needs to be a lot of formulating, a lot of conceptual activity to see where, in the middle of the spectrums, the technology is ready, the economics are not too limited. There are serious problems to be solved. And now finally, we go to the mail service and the telephone service. We see that here are things that are pretty well in hand already and they raise the question: how would an interuniversity network intermesh itself with the established communication media? TSCHIRGI: I'll comment at least on the first part. The archival function that I would certainly focus is the library problem. That's because the museum aspect is a very small, and, in a sense, trivial problem compared to the library problem. It is a matter primarily of retrieval and dissemination. Three pharaceutical companies have told me they now regularly have studies done in their laboratories that they know have been done elsewhere, but it's found less costly to repeat the experiment in the laboratory from scratch than to try and find it in the literature. When this is presented, it immediately seems to me that we're at the brink of some kind of disaster as far as information storage and retrieval is concerned. So yes, that's why I would put that one first and not worry about the museum for the time being. CORRIGAN: In pondering this question of where do we go from here, I get impressed, of course, with the tremendous input of various members of the group. In Bob Tschirgi's statement of the information model specifications; he said there's really one thing we're concerned with and that is how much, what kind of information and when it's presented according to some priority. This is one referents, so that we have some planned specifications in terms of what we're concerned with. Also the statement: what kind of information flow nets are appropriate to make a system operate effectively. I look at that and then I also think in terms of the demand problem, the demands of the university but even more broadly stated, a requirement for a shorter response time between innovation and implementation to meet some rather pressing problems, against a world which is changing in a very rapidly ever-increasing rate. Another consideration is a requirement of better utilization of whatever resources we have in some coordinated fashion. We have to come up with a better communication model between ourselves, some way of intercommunicating in order to evolve and develop purposive activities to resolve some of the needs. Then is the third referent I considered as I came to this conference on computers and universities, and I have learned a tremendous amount. One thing in particular was how rapidly this moved from a technical approach to a much broader university system concept involving even the latest configuration of the whole function of the community and the personnel interacting. Within that is the understanding that, against demand and against information requirements are certain limits and constraints to be faced within that university concept, limits in the sense of resources, of personnel of qualified people, of capital, of facilities and so forth within which we can operate to fulfill needs. Secondly, there are certain constraints we're faced with like the acceptable or appropriate role of the university as the community defines it, and the university is making its contribution serving the community against this time-change spectrum. Within this, it appears to me where we have really an urgency to move in the most expedient and the most concise manner, that the concept of computers and universities or computers per se and other innovations have to be conceived of and looked at in a broader context, some of which were brought up yesterday; namely, we are really concerned in terms of coming up with communication modes and ways of interacting, the most efficient ways of going, of first of all clearly defining what our purposes are. That is, what are the objectives, at least at some limited time basis, which are established in some measurable way, whether we're talking about the dimension of instruction or we're talking about the dimension of public service or whatever, that we are communicating? If we were going to go on a trip, the first thing we would decide on is where we're going to go, and I think we might attempt to address ourselves to this because until we know exactly what it is we're trying to achieve, in measurable ways, we can hardly address ourselves to the problem of efficient utilization of personnel resources to achieve these stated objectives. We could go in a lot of directions, but where we have limited resources, what is the most optimum way to go? There's also the problem of the quality of the outputs or products in terms of defined purposes and goals and objectives. With this is the quality and efficiency of the processes for achieving these stated purposes and producing quality-assured products, whether it's contributions in the terms of predictable learning or quality-assured instruction or whether we're talking about public service. I'm talking then about a system of planning and design which must take these things into account to determine relevancy of purposes and objectives and have a sensing mechanism as part of our design which is continually sensing the changes in the real world requirements and accommodating those changes in the redefinition of our objectives. I think only within these contexts and until we address ourselves to these ideas, these postulates, can we take a look at models of implementation which are appropriate to the achievement of these, models such as computer-assisted instruction. There are various ways and means by which we could implement computer-assisted instruction, but what, against the objectives, perceivably might be the most appropriate? The one of computer-assisted management and administration is the same thing. So are communication information networks, between universities or facilities designed for cost effectiveness. Until we have some functions defined based on limited objectives which we can build on, it's fairly difficult to utilize all our resources in the most efficient way. In looking at computers and universities I must evaluate it in the light of these other things. I would have to have more data to proceed. Although this conference is not directed to that particular set of objectives of planning, I think it would be most appropriate and I would like to have two more weeks based on what I know now to go from there and hear more about such things. I think they're in the realm of closure within a group such as this. This brings us right back to the first statement of once these things are done, how much, and what kind, and when certain kinds of information take on certain priorities, whether we're relating to models of learning, models of instruction or models of administration and management. That's where I think we should go. SNYDER: Anyone else like to comment on this general thrust, sort of a question of what we might do after we disband this phase of our operation? MILLER: One thing that we might talk about with EDUCOM is the creation of centers for information science or for systems science in universities. It seems to me that the universities in EDUCOM are attempting something we've never done before, which is to turn their own expertise back on themselves. The very use of concepts of information flow implies some sort of input-output equilibrium feedback philosophy in all probability. At least there seems to be general agreement about the importance of this approach in electronics engineering, communications science and so on. Should we have somewhere in the stoa a number of universities around the country, more than we have now, or a group of generalists who are interested in applying this sort of philosophy and increasing the basic science of understanding the university as a system, the individuals and groups in it and so on, so that these applications we're talking about will be more effective? Perhaps something can be done by the universities to develop departments of this sort. Certainly they will be highly interdisciplinary departments, like the departments of biophysics or the departments of biochemistry of the previous generation because no one is an expert in this area, but don't we need to have more of these around the country than we do at the present time? GERARD: A department of university planning? MILLER: Well, yes, a department of general studies which has the systems orientation. One form of application is certainly to the university itself. That might well be the first one, but it obviously has applications in other areas as well. Most of these units where they now exist in universities are under other guises, but there is one exception, the School of Information Sciences at Georgia Institute of Technology. SNYDER: I have a feel that maybe we are ready to wrap this up.

GERARD: Dick has encouraged me to prepare some sort of valedictory or benediction and I am happy to take a moment or two to do this. I was thinking this morning earlier that out of World War II came at least two major kinds of military outcomes and social fallouts: the great effort of the atom bomb, atomic energy, produced the fallout of really effective tracer, radioactive tracer, resources which I would say perhaps vastly more than any other factor, were responsible for what is coming to be called the New Biology, the complete revolution in knowledge and understanding of living systems which characterizes the middle third of this century. On the other hand, the electronic side, there developed computers and radar, telemetering, which have given us the kind of technology which underlies what we've been talking about all week, which I'm profoundly convinced will similarly bring about the new social science or the new behavioral science, and I strongly suspect this will be the era of the last third of the twentieth century, all of these going on beyond. Now in the area of behavioral science, certainly the field of education is the largest and perhaps the most important that has not really moved under the impact. In any event, we do now have, with these newer fallouts from technological advance and including the mathematical developments that accompanied them, the possibility of taking what had to be in the past rather nebulous mental models with which we were trying to gain understanding and making them sufficiently precise, manipulable, so that one could make predictions, explore their validity, simulation or in any other way, and really come to grips with them and thereby find out that they're wrong and in what way one has to modify them and improve them. I think education is going to go through a major revolution in the next decade, if not years. The financial support is coming in, new sorts of people are being attracted to it, the goals are being reexamined, as they were this morning so effectively. The institutional aspects, the structuring of the whole process, all this is in the state of magnificent and health flux from which I see tremendously exciting outcomes. Well, where do we go from here? I was delighted that several of the last comments had to do with the followup.

There will be this immediate followup of the conference at least. There has been a complete recording of the proceedings. As soon as these can be effectively transcribed and before they are seriously edited I'm going to suggest that we consider transcribing this on mimeograph forms, rather than on paper and just send out at once to all of you a full documentation so that you can have it in a matter of weeks rather than months. At that time, I hope you will do whatever editing of your own material you want, anybody else's you can make suggestions about, that you will add particulars, references, concrete items, facts, (this matter of the financial support of computers versus libraries and universities and that kind of thing) any additional pearls, especially the things that you were eager to say but never got a chance to in the press of intercommunication, and, by all means, send it and you don't have to wait for the transcripts for that, any concrete suggestions that occur to you along the lines of those that were put out this morning, or on utterly different lines, what you think should be done to keep the momentus that we've gained. I will take the liberty of quoting Oliver Selfridge who, before he left last night, said he might not get a chance to see me again and he wanted to say that although he'd been to many meetings in his life, he couldn't remember one that had been more exciting or rewarding intellectually, and I prized that, particularly from a hard-headed, honest man like Oliver. I have the same feeling. I think many of you are pleased with the experiences. It is a group that mostly has not been together before. It's the kind of focusing of interest that could be excitingly productive in the future. Now it's very easy to say-"Let's have another meeting and do some more of it," but that is not necessarily the right answer. In any event, I will welcome, and I'm sure the Office of Education will welcome, any suggestions for followup of the excitement and momentum that I think we have gained this week.

I have only one more thing to say, the obvious one. I am enormously grateful to those of you who did make it so worthwhile. The input has been tremendous and rich. The speakers, particularly the formal speakers, but nearly as much, everybody, I think without exception, brought really important insights and ideas and information. I certainly want to thank the recorder and the girls who carried the load of the arrangements. Thank you very much for coming.

- END -